THE

FOUNDRY TRADE JOURNAL

WITH WHICH IS INCORPORATED

THE IRON AND STEEL TRADES JOURNAL

VOL. 55 Thursday, August 20, 1936 No. 1044

PUBLISHED WEEKLY

Subscription Terms: 15s. per annum.
Foreign and Colonial: 17s. 6d. per annum.
All Subscriptions are payable in advance.

All Communications to be addressed to the Editor, the Advertisement Manager, or the Publisher of

THE FOUNDRY TRADE JOURNAL, 49, WELLINGTON STREET, LONDON, W.C.2

Telegraphic Address: "Zacatecas, Rand, London."
Telephone: Temple Bar 3951 (5 lines).

THE FOUNDRY TRADE JOURNAL IS THE OFFICIAL ORGAN OF

The Institute of British Foundrymen
The Institute of Vitreous Enamellers
The National Ironfounding Employers' Federation
The Welsh Engineers' and Founders' Association
and
The Foundry Trades' Equipment and Supplies Association

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BRITISH CAST IRON RESEARCH ASSOCIATION

The Registered Office and Laboratories of the B.I.C.R.A. are:—
21-23, ST. PAUL'S SQUARE, BIRMINGHAM
Telephone: Central 1885. *Telegrams: CIRA*
The B.C.I.R.A. Scottish Laboratories are:—
Foundry Technical Institute, Meek's Road, Falkirk
Telephone: 332

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A Case for Action

The foundry industry is particularly well served by its technical organisations, which are doing excellent work in disseminating knowledge about cast alloys, but it does appear to us that some effort should be made by them to influence designers in such a way that they will not merely be "castings conscious," to borrow a phrase from the publicity mongers' vocabulary, but also that they will be in a position to use cast alloys to the best advantage. This involves preparing drawings which will give a simplified moulding proposition associated with a stronger article. We recently had through our hands a really practical pamphlet on designing sheet metal work for vitreous enamelling, whilst everybody is cognisant of the mine of information there is available for the designer of weldings, yet similar information for the designer of castings is hard to find. The steel industry has a special organisation aimed at increasing the consumption of steel. It views such articles as cast iron baths as fair game for replacement by steel pressings, and cooking ranges, radiator segments, gutters and pipes of various kinds enter the same category.

We do not suggest that the founding industries' scientific bodies are the proper organisations to undertake commercial propaganda on behalf of the industry, but they might usefully draw the attention of the various employers' federations to the need for concerted effort. We are not particularly disturbed as to the ultimate outcome of anti-castings propaganda, when we take the long view, but we do feel that a little diplomatic intervention may tend to keep the campaign within reasonable limits. For instance, the wholesale replacement of cast iron baths by steel would reduce the consumption of pig-iron, as does the substitution of castings by weldings. The co-operation of the blast-furnace owners could usefully be sought to maintain a well-balanced programme of synchronous development of both cast iron and steel. When we have placed the position of the foundry industry in its proper perspective before various high officials of the steel organisations, our views have invariably been accorded a sympathetic understanding. Obviously, if no approach be made by the foundry industry, the efforts of the steel trade will be directed towards the replacement of cast iron articles by steel pressings, and who is to blame them?

An Early London Foundry

A contemporary has given some interesting details of an early London foundry very near Fleet Street, established by Henry VIII for the manufacture of bronze cannon up to eight inches bore and over ten feet in length. When Henry came to the throne, the only foundry capable of casting bronze guns was in the Tower, on the eastern side, near St. Katherine's Dock. The leading craftsman was Humphrey Walker, a skilled bronze founder, who made the railings round the tomb of Henry VII in Westminster Abbey. Prior to this date it is said that guns were made of bars and rings of wrought iron welded together, this forging operation being carried out in the Tower and in forges all over the country. The supply, however, was not equal to the demand in the armaments race of the period, and Henry VIII imported foreign armourers to work at the Tower and at Greenwich.

He installed a Frenchman, Peter Baude, and the brothers Owen as gun-founders in Houndsditch, near Aldgate. When they proved unable to meet his requirements, he brought a family of Italians from near Ravenna about 1520. They were named Arcanus, and it is apparently they who were established in Salisbury Place, near Fleet Street. In 1531, they shared with other gun-founders nearly 200 tons of scrap ordnance for melting down. Of this family, Francis is recorded as "master of mines," and another, Archangel, was styled the "King's gun-founder." He visited Berwick, Kelso and Calais as an expert on fortifications, to design new or to improve existing defences. For a period of eight years there are records of payments to this family for guns of various sizes, and their work is decorated with the Tudor rose and engraved with their name. Although at least one became naturalised, one of their latest productions in the Tower is signed "Arcanus of Cesena," their native town. Nothing more is known of them after 1545, or, indeed, of their foundry, and its exact location in Salisbury Place is not known. Our authority presumes that it was near Salisbury House, on the site of which the square of that name stands, a name not found elsewhere in London.

Andrew Carnegie Research Fund

The Council of the Iron and Steel Institute are prepared to make annually a limited number of grants from the Research Fund founded by the late Mr. Andrew Carnegie in aid of metallurgical research work.

The object of the scheme is not to facilitate ordinary collegiate studies, but to enable students, who have passed through a college curriculum or have been trained in industrial establishments, to conduct researches on problems of practical and scientific importance relating to the metallurgy of iron and steel and allied subjects. Candidates, who must be under 35 years of age, must apply before September 30, on a special form to be obtained from the secretary of the Institute.

The value of the grant will depend on the nature of the proposed research work, but the maximum amount granted in any one year will, as a rule, not exceed £100. The grant will be divided into four instalments. Of these, the first will be paid on or about January 1, and the second and third on or about July 1 and October 1, subject to the receipt of adequate progress reports. The final instalment will not be paid until a complete report on the entire research, in a form suitable for publication, has been received; this should be submitted not later than the following May 31 (in exceptional cases, an extension of an additional year may be granted). The Council may, at their discretion, award a further grant in aid of any particular research work, which seems to them sufficiently meritorious to justify further assistance.

The results of the research shall be communicated to the Iron and Steel Institute, which will have the right of priority of publication in full, and will bear the whole costs thereof; subject to the approval of the Council, they will be printed in the "Carnegie Scholarship Memoirs," a volume of which is published in December of each year. Papers of particular interest may be selected for discussion at general or additional meetings of the Iron and Steel Institute.

In considering the allocation of grants, the Council cannot undertake to accept any particular proposal, but will be guided by the nature of the subjects proposed for investigation, giving preference to those which, in their judgment, appear to be of the most practical advantage to the iron and steel and allied industries.

Founding of Pressure Castings

In his amended reply to the discussion on the Paper he presented to the Glasgow Conference of the Institute of British Foundrymen, Mr. Judson points out that a Paper on the two cupola process was given to the American Foundrymen Association meeting in Detroit four years ago.

The temperature (1,410 deg. C.) of the metal at the spout, referred to in Mr. Judson's Paper, was taken with no correction made for emissivity.

In further reply to Mr. Harbach's remarks, MR. JUDSON writes that the steel used is normal railway rail scrap and shows the following analysis: T.C, 0.55; Si, 0.15; Mn, 0.75; S, 0.06; and P, 0.05 per cent. The pig-iron used with the steel rail charges, for the two-cupola process, has a silicon content of 15.3 per cent. The average manganese loss in all of the cupola operations in which Spiegeleisen, containing 20 per cent. Mn is used, is 40 per cent.

The use of the returns from the high-duty heats has already been covered. The amount of these returns is so small as compared with the rest of the tonnage that their use in other mixtures is not a serious matter. The foundry does not use the high-duty returns in high-duty mixtures, preferring to start with as low a graphitic-carbon content in the steel-rail charges as possible. The phosphorus content of the common iron will be dealt with later.

Reference in the discussion was made to a mixture containing 2.40 per cent. total carbon and 1.35 per cent. silicon as requiring adjustment. Never having run such a mixture it is impossible to say definitely. These figures are the low limit, and the foundry has never obtained both in the same heat, and in fact has not attempted to run such a mixture.

The remainder of the discussion which pertains to low-carbon irons is answered by the following. Hundreds of tons of castings for high-pressure pumps, operating on crude oil and petrol, at pressures of 900 lbs. per sq. in. or over, have been cast from mixtures having 2.50 to 2.70 per cent. T.C and 1.50 to 1.70 per cent. Si. The main thought behind the low-carbon iron described is that of pressure-tightness rather than high strength. Tensile strengths, always over 19 tons per sq. in., are obtained from specimens cut from the walls of actual castings and not from test bars, are ample. Waster castings are no problem, and in fact, there are many jobs that the foundry insists on casting with this low-carbon iron because of an almost complete freedom from leakers on test.

The last part of the discussion refers to the phosphorus content of the common iron. The phosphorus content of the pig-irons used for years ran 0.45 per cent., which is not low, and does not command a premium. It is only when the phosphorus is specified below 0.30 per cent. that a premium has to be paid. Incidentally, no attention is paid to the phosphorus content when machineability is being considered.

A Moulder's Sand Castle

After reading our "heat wave" leading article on "The Founder on Holiday," Mr. George Hall, who is well known in London, Lancashire and Yorkshire foundry circles, discovered a photograph taken some twenty-five

years ago of an effort he made to amuse his son—now an officer in the Royal Air Force, during a summer holiday. Whilst we would welcome the inspection of similar efforts we have no intention of furthering the art.

Correction.—We regret that Fig. 10 of Mr. H. Greenhouse's Paper on page 122 of our last issue was printed upside down.

Book Review

La Malleable. (Malleable Cast Iron) by Maurice Leroyer. Published by Dunod, 92, rue Bonaparte, Paris (VL). Price by registered post 50.60 fr.

This book is essentially an up-to-date treatise on the metallurgy of malleable cast iron, and presupposes a fair metallurgical knowledge on the part of the reader. The author deals adequately with white-heart, black-heart, intermediate and what is called in America, "pearlitic malleable."

To well-read and experienced malleable foundrymen the book contains nothing new, but it does bring together in an excellent manner the results of modern researches.

The theories of graphitisation and decarburisation; the influence of chemical composition upon casting properties, graphitisation, decarburisation and mechanical properties, and the influence of the factors entering into the annealing processes are exhaustively treated in three separate chapters. These contain the best material in the book.

The author contents himself with one chapter upon manufacturing methods and this is of little value. There is a useful chapter on what the author calls "finishing processes," namely machining, heat-treatment after annealing and protective coatings. An excellent inclusion is a chapter dealing with defects peculiar to black-heart and white-heart malleable castings. The author explains the causes and preventive and ameliorative treatments. The book concludes with a chapter on special malleables. This summarises the existing information on the effect of alloying elements in malleable cast iron.

Throughout, the author stresses the phenomenon of "temper embrittlement" (in U.S.A. "white ferrite") in black-heart malleable, but makes no reference to the immunity from this trouble of English black-heart. The output of black-heart malleable in England is over 25,000 tons per annum, and the whole of this production is free from "temper embrittlement" because of the low phosphorus content of the hematite pig-iron from which it is produced.

Whilst there is an extensive bibliography the author has apparently overlooked a number of publications in the Proceedings of the Institute of British Foundrymen, which would have enhanced his work, particularly in reference to white-heart malleable.

The book contains many excellent photomicrographs interspersed throughout the text. Reference to these and to the equilibrium diagrams would have been facilitated had they been included in an appendix. Numerous other diagrams and sketches are included and for the most part these are conveniently situated in the text.

This book will prove a valuable addition to the library of manufacturers and users of malleable cast iron, and will be particularly useful to those workers who encounter problems of graphitisation and decarburisation.

A. E. P.

DURING THE JUBILEE CELEBRATIONS of G. & J. Weir, Limited, Glasgow, Lord Weir, chairman, drew attention to the modern conditions under which the employees now worked. He also stated that the usual spring holiday would be known as the James Weir Commemoration Day, and the employees, save the office staff, would each receive 10s. if they are over 20 or 5s. if they should be under 20 years of age on that day. Mr. Robert Stark, the oldest employee of the firm, made a presentation to Lord Weir on behalf of the directors and staff. Mr. J. R. Richmond, C.B.E., one of the directors, then presented to Mr. Stark a gold watch as a mark of appreciation of his long service with the firm.

Pearlitic Malleable Cast Iron

AN AMERICAN SYMPOSIUM

A scheme for the rational classification of malleable cast iron is disclosed in the Introduction to this symposium, which was organised by the American Society for Testing Materials, whilst a later section deals with Producers' Data

I. INTRODUCTION

It is always well to begin such a symposium as this by defining its scope. The present prevailing opinion of the interested persons in the American Foundrymen's Association is that any material which starts out as white cast iron and is subsequently heat-treated to produce graphitisation is to be called pearlitic malleable if the graphitisation be purposely terminated when sufficient combined carbon remains significantly to affect the properties of the product. The combined carbon usually is present as pearlite, although it frequently may be present as sorbite, or might be martensite or some other form of decomposition product of austenite.

These facts were discussed by the various committees of the American Foundrymen's Association and the term pearlitic malleable adopted, even though not precisely justified metallographically, since the prevailing structures are laminated or granular pearlite and sorbite, between which definable distinctions are difficult to make at least simply. It is even possible that primary cementite should be considered, although the instances where its existence is *intentional* and also in *significant amount* are at present extremely rare.

This definition excludes material containing *significant* amounts of graphite as cast, for in that case the material is not initially white cast iron, and also excludes all those substances, many closely allied to malleable or pearlitic malleable, which as cast are high-carbon steels instead of cast iron, that is, which are solid homogeneous single-phased alloys at some temperature.

The distinction is convenient for the purpose of classification and also for the purpose of this symposium, for the graphitised steels have not yet been sufficiently studied, publicly, to warrant a discussion of their characteristics. Be it remembered also that metal is to be called pearlitic malleable if it purposely contains significant amounts of combined carbon irrespective of whether this constituent is residual in character or has been produced by the recombination of carbon earlier thrown out by graphitisation.

These definitions have been adopted as convenient for the purpose, and having a certain support from the American Foundrymen's Association, while recognising that other definitions or other names might be proposed for the defined alloy.

Historically, it is probably safe to say that during the first one hundred years of the "black heart" malleable founder's art the intent was always to produce a completely malleableised material, that is, one consisting of ferrite and temper carbon.

Sub-Division of Pearlitic Malleable Cast Irons

The pearlitic malleables are capable of systematic sub-division for the purpose of study and discussion (see Table I). To begin with, they may be classified into two major divisions:—(I) Metal produced by interrupting graphitisation before completion; and (II) metal produced by reheating completely graphitised alloys.

Division I can be sub-divided into two classes: (A) Metal having a composition similar to that of malleable iron, in which the retention of combined carbon is due to a shortening of the annealing cycle, and (B) metal to which various retarding elements have been added to secure a retention of combined carbon, even with extensive heat-treatment.

Division II contains, in practice, alloys of class A only, for obviously if one is completely to graphitise the metal, there is no point in retarding that operation.

In either division metals can be produced in which the combined (better agraphitic) carbon is present in various metallographic forms, as for example (1) martensite (or troostite); (2) sorbite; (3) laminated pearlite; (4) granulated pearlite produced from the laminated variety by surface tension forces, and (5) spheroidised structures produced by the heat-treatment of (1) or (2) to produce coalescence of cementite particles. Each of these may constitute a group.

Lastly, there is possible a number of types of distribution of ferrite and decomposed austenite; these are: (*a*) a random granular dispersion of ferrite and (usually) pearlite grains similar to those in a normalised hypo-eutectoid steel; (*b*) temper carbon surrounded by ferrite and surrounding the ferrite crystallities of pearlite or similar ingredients; (*c*) a network of metal containing agraphitic carbon surrounding grains of ferrite; and (*d*) a homogeneous metallic matrix.

This system of classification does not include the possibility in division I or II, class A, of metal containing also vestiges of primary cementite. One should have originally divided the field into families: (alpha) containing no primary carbides, and (beta) containing primary carbides; remembering that beta is so far mainly of academic interest. Under beta it might then be necessary for completeness to include also a sixth group to cover a completely ferritic matrix containing both graphite and cementite. Commercially there are as yet no members of such a family and group in use. It is also true that not all the groups and types are compatible among themselves or exist in every class and division.

For example, type *c* is so far produced commercially only in division II and in group 1 as a transition step and group 2 in the final product. The heat-treatments required to produce some types are incompatible with the production of certain groups, for example, type *b* does not readily produce anything but group 3, for the heat-treatment which produces ferrite bull's-eyes also produces laminated pearlite and so on.

Heat-treatment of white irons from which pearlitic malleable of the alpha family is to be produced invariably begins by holding at temperatures above their A_1 points for a sufficiently long time to destroy all primary carbides. This is possible even in the presence of the usual retarders, though it is probably impossible in the presence of vanadium. The carbide of that element is either thermodynamically stable or its transformation rate is so slow as to be negligible in practice. Its iron-carbon alloys probably cannot, therefore, produce other than metal of the beta family, and in any event no commercial use has yet been made of the persistence of its carbides. If the initial heat-treatment has been at temperature considerably in excess of A_1 it will be necessary to lower the temperature to near that temperature and await equilibrium, if alloys of the alpha family are to be produced, or else rejected proeutectoid cementite might conceivably persist.

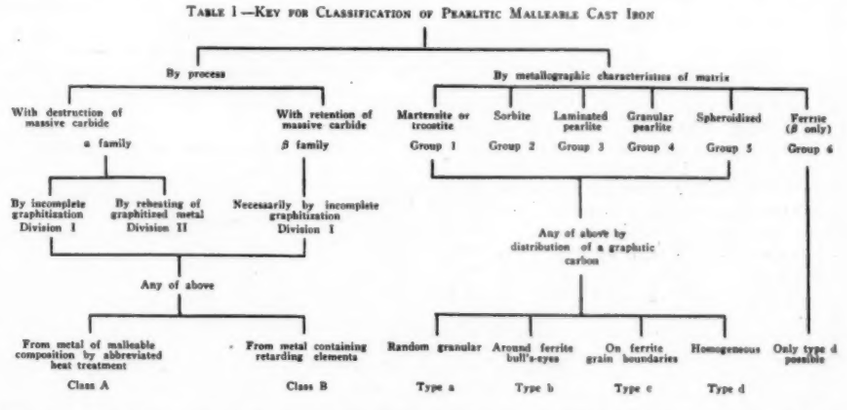
Having now an alloy consisting of graphite and austenite saturated with carbon (probably as cementite) at the eutectoid temperature, the subsequent heat-treatment will depend upon the type and group to be produced. Clearly, if one quenched rapidly, the matrix will become a homogeneous mass of martensite and the result will be group 1, type *d*.

If it be desired to produce an alloy to be less hard, it can be tempered just as the steel treater would temper a quenched tool steel and convert it into group 2 or 5. It will remain of type *d* if the heat-treatment involved does not result in further graphitisation. The *rôle* of alloys in producing this result will be described later. If graphitisation accompanies this heat-treatment, the resulting carbon is usually deposited upon the already existing nodules, and frequently these become surrounded with ferrite, resulting in the simultaneous conversion from group 1 and type *d* to group 5 and type *b*. It is, under favourable circumstances, possible to cool at such a rate as to produce homogeneous sorbite, producing an alloy of group 2, type *d*, and sometimes to heat-treat this to produce a *5d* alloy or more generally a *5b* alloy.

If cooling through the critical range is somewhat slow, ferrite crystallises as "bull's-eyes" around the temper carbon, and the remaining austenite is converted into laminated pearlite, an alloy of characteristics *3b* resulting. It is practically impossible to prepare any other kind of alloy by such a heat-treatment, although *4b* and *3d* can occasionally be found. Alloys of type *a* are usually of group 2 or 3 and result apparently when cooling is quite slow through part of the critical range and then more rapid, or in alloys falling in division II if the recombining heat-treatment be not prolonged.

A completely malleablised iron heated sufficiently long above its A_1 point is, from the metallurgist's viewpoint, identical with a white iron held to equilibrium at the same temperature. Industrially, the latter course is usually preferable, save now and then, for the purpose of altering the composition of an existing malleable casting. When an annealed casting is heated but little above its A_1 point, recombination of the carbon begins at the grain boundaries, and alloys of type *c* result. On quenching, these are of group 1 or 2, depending upon

TABLE I.—KEY FOR CLASSIFICATION OF PEARLITIC MALLEABLE CAST IRON



the quenching medium, and further heat-treatment may convert them from groups 1 to 2 or 5 or from groups 2 to 5. Possibly a 3*d* alloy could be prepared by air-cooling instead of quenching, though this is not done in usual practice.

The rimmed castings first mentioned have a certain vague relationship to the type *c* casting in that in the former the boundary of the casting contains combined carbon, and in the latter the boundary of an individual grain. A type *c* casting thus consists of myriads of rimmed crystallites. This is as far as the analogy extends for the reason that the rim in a casting is quite different from that for an agraphitic grain boundary.

Rate of Graphitisation

Graphitising rate depends, among many other variables, very greatly upon the number of graphite nodules present. Decarburisation, as at the surface of a casting, reduces the number of such nodules and retards graphitisation, especially below A_1, in such a manner that locally at the surface a casting may well be in the classification 3*d* when it is a normal malleable within.

It is probably simplest to classify such castings by their rim characteristics. They are substantially always of division I, but may fall either into class A or B, usually the latter. Possibly it would be logical to create for them a separate family which would occasion no confusion, since they never contain primary cementite. Alternatively one may differentiate between rimmed and unrimmed castings. Quite frequently castings have 3*d* rims and 3*b* centres; in fact, a transition in group 3 castings from types *b* to *d* as one proceeds from the centre toward the surface is the rule rather than the exception.

The rate of graphitisation of any alloy is specific to that alloy. It may occasionally be that this rate is so rapid that it is convenient to reduce it by the addition of suitable retarding elements in order to facilitate a particular commercial process. The retarding elements so far found useful are predominantly manganese in amounts up to ½ or 1 per cent. more than would be used for a similar alloy in making ordinary malleable castings; chromium, which is extremely energetic and hence most often used in amounts from less than 0.1 to, say, 0.3 per cent., and in some cases molybdenum, which acts but mildly and is usually used in amounts from 0.1 to 0.5 per cent.

Fortunately all three of these elements affect graphitising rate below A_1 (second-stage graphitisation) much more than the high-temperature first stage. The use of alloying elements presents particular advantages when the metallurgist is confronted with the conversion of 1*d* structures into 2*d* or 5*d* and the occurrence of free ferrite of type *b* is to be avoided, or minimised.

Not only is graphitising rate at a given temperature inseparably connected with a given metal, but so is the time required to spheroidise that metal to a given extent. It may happen that the spheroidising time is such as would cause sufficient additional graphitisation to liberate undesired free ferrite. The addition of a retarder then is indicated strongly, for the retarding elements are of much greater effect on graphitisation than on spheroidising.

It is quite evident that out of the two families, two classes and two divisions, each further subdivided into five or six groups, any of which could fall into any of four types, a great variety, actually 192, of alloys are imaginable, some of which might be produced by numerous combinations of alloy and heat-treatments. All this does not include the rimmed metals as special cases. In fact, only a rather limited selection from this rather broad field have become commercially significant, and a fairly large number may be considered incapable of industrial production.

The actually used pearlitic malleables are the following: Rimmed castings, division I, classes A and B; rim 3*d*, core 3*b* or ordinary malleable which might be designated 6*d*. Unrimmed castings: Division I, classes A and B, group and type 3*d* and 3*b*; division I, class B, group and type 2*d* and 5*d* rarely and perhaps inadvertently 2*b* and 5*b*; division I, class B, 3*a*, and division II, class A, 2*c*, 5*c*, 1*d*, the latter rarely. There are thus only fifteen or seventeen distinct pearlitic malleables in common use, some of which differ in manner of production rather than in properties. Even so, the field is so large as to make generalisation difficult.

Pearlitic malleable differs from ordinary malleable in the character of its matrix. The metals will therefore differ approximately as their matrices differ or as steel differs from ingot iron. It is safe to say that the pearlitic malleables are all stronger and less ductile than normal malleable and have a higher elastic ratio.

They machine less readily, and have a higher indentation hardness. There are reliable indications that the fatigue ratio of these metals is near the expected value of 50 per cent. Since impact resistance is a function of both ductility and strength, they may have either higher or lower impact values than normal malleable. Their permeability will be less; remanence and coercive force will be greater; their electrical and thermal conductivities less than malleable and they are denser. Their net shrinkage from pattern size is slightly less than that of malleable due to incomplete graphitisation. Beyond these predictions the properties of a given product are largely a matter of experiment.

II. PRODUCERS' DATA

Pearlitic malleable iron seems to have a large potential field, due to wide variation of physical properties possible by heat-treatment. It is being produced in the air furnace as well as in the electric furnace and is being sold under several trade names with some slight variation in method of manufacture, and also with some variation in the microstructure accomplished by the heat-treatment.

High Silicon Pearlitic Malleable

According to one producer, this iron usually contains a total carbon of approximately 2.50 per cent., silicon approximately 1.50 per cent., manganese 0.35 per cent., and a maximum sulphur and phosphorus content of 0.05 per cent. The silicon, of course, will vary according to the section being produced, and the time required for heat-treatment will vary considerably with the section.

Before describing the heat-treatment it might be well to indicate the reason for the proportion of elements in the composition. Experimental work with various amounts of carbon beginning at 1.5 per cent., indicated that it was impractical to make castings commercially with such low carbon. The liquid shrinkage was extremely bad, and in many cases it was found impossible to produce sound castings. Experiments were conducted running progressively higher carbon, until what seemed to be an ideal compromise between castability and physical properties was reached. The object of the foundry is to keep as constant a total carbon as possible, in order not to complicate the heat-treatment problem. Therefore, it was decided to maintain 2.5 per cent. carbon in all castings regardless of section. The silicon should range from 1.30 per cent. in sections ¾ to 1 in. thick, up to 1.60 to 1.70 per cent. for sections ⅞ in. thick.

The heat-treatment cycle depends upon the physical properties desired. The range of tensile strength possible is from 24.5 to 45 tons per sq. in. The elongation, generally speaking, will vary inversely as the tensile strength. An iron with a tensile strength of 24.5 tons per sq. in. properly heat-treated, should show an elongation of 12 to 15 per cent., while one with a tensile strength of 45 tons per sq. in. should show an elongation of 3 to 4 per cent. The yield point seems to be approximately 75 per cent. of the tensile strength, regardless of the method of treatment and the elongation. This iron is cast white, and, if it is desired to experiment with the optimum mixture, the theory is that the silicon should be just sufficiently high to produce a white iron in the casting. The nearer a mottled iron can be approached without actually showing the mottle, the more perfect will be the response to heat-treatment.

A typical heat-treatment for castings with sections from ¼ to ¾ in. thick to produce the lower strength, higher elongation material is as follows:—Heat 4 hrs. at 940 deg. C. Cool to 718 deg. C. Hold at this temperature 4 hrs. Furnace cool to 590 deg. C. and air cool. This specification for heat-treatment has been written to be given to the commercial heat-treater. What actually is desired at the stop-off on the way down is that the load shall pass through the lower critical as slowly as possible to accomplish the greatest amount of graphitisation. The time of dropping from 940 to 718 deg. C. is not important; except from a commercial angle, it should be dropped as rapidly as possible.

Better physical properties can be obtained by heating to 940 deg. C. for 4 hrs., cooling in the furnace to about 815 or 840 deg. C., oil quenching, and then reheating to about 690 deg. C. and holding at this temperature for varying lengths of time, depending upon the properties desired. Complete malleablisation will take place at approximately 12 hrs. The iron is spheroidised by this process, the result of the quench being a sorbitic pearlite. A 1-hr. draw at 718 deg. C. discloses at high magnification, a perfect spheroidisation.

The combined carbon drops throughout the heat-treatment and the spheroids become fewer, until at about 12 hrs. the combined carbon practically has disappeared. Physical properties, both elongation and strength, will be about 5 or 10 per cent. higher by the quench treatment than by the slow-cooling treatment described previously. After a 1-hr. draw the following physical properties should be expected:—Tensile strength, 40 tons per sq. in.; yield point, 31 tons per sq. in.; Brinell hardness, approximately 235; and approximate elongation, 4 per cent. As might be expected, experience has proved that the wear resistance of this iron is comparable to that of good high-duty grey irons, the spheroids or carbides apparently furnishing a support for the load similarly to the plates in lamellar pearlite.

Physical properties of this iron, particularly in the quench treatment, can be improved by the use of molybdenum or nickel. It is extremely important that no chromium be present if a minimum time is desired for the heat-treatment cycle. The stabilisation of the carbides by chromium is easily detected if the chromium exceeds 0.05 per cent. in the charge.

A much more simplified system of producing fine pearlite has recently been developed which gives about the same physical properties as previously mentioned. However, the heat-treatment is much simpler, as follows:—Heat to 940 deg. C. and hold for 4 hr. Cool in furnace to 675 deg. C., preferably at the rate of about 40 deg. per hr. Without removing the material from the furnace, reheat to 815 deg. C. and air quench. This produces a structure in which there is no free ferrite—no bull's-eye effect—such as is quite common in a modified malleable.

Another contribution which we might mention is that research work along this line indicates that it is of extreme importance to charge the silicon with the cold charge in the furnace. That is done to secure a maximum amount of silicon in the casting for the purposes of secondary graphitisation, at the same time giving a minimum tendency toward primary graphitisation. Regardless of whether one accepts the nuclei theory, it is an admitted fact that disturbances caused by the addition of practically any of the materials except steel tend to promote primary graphitisation, which is undesirable in this type of work.

Copper-Bearing High Manganese Pearlitic Malleable

Another producer manufactures three grades of pearlitic malleable iron, approximately, according to the following tabulation:—

White iron analysis.	Grade No. 45009.	Grade No. 53007.	Grade No. 60005.
C, per cent. ..	2.40	2.40	2.40
Si, per cent. ..	0.95	0.95	0.95
Mn, per cent. ..	0.95	1.15	1.35
S, per cent. ..	0.065	0.065	0.065
P, per cent. ..	0.17	0.17	0.17
Cu, per cent. ..	1.00	1.00	1.00
C.C. in annealed iron	0.20	0.40	0.68

The physical properties as determined from the standard test specimen* for malleable iron of the American Society for Testing Materials are as follow:—

	Grade No. 45009.	Grade No. 53007.	Grade No. 60005.
Tensile strength, tons per sq. in.	27	31	36
Yield point, tons per sq. in.	10	24	27
Elongation in 2 in., per cent. ..	9	7	5

The first table shows the approximate hard iron analysis, and the approximate combined carbon content after annealing. The physical properties are indicated in the second tabulation, and are minimum properties which are frequently exceeded. These three grades of pearlitic malleable iron are made by ladle additions of ferro-manganese and copper to the ordinary run of white iron for malleable castings. The only difference between the hard iron malleable analysis and those shown in the above tabulation is in the manganese and copper. In normal white iron for the production of malleable castings, the manganese is maintained at 0.30 per cent. and copper is omitted. The physical properties shown in the tabulation are attained by the regular malleable annealing cycle. The producers' opinion is that the physical properties mentioned could be improved quite definitely by the use of cycles especially adapted to the increased manganese content, but for practical reasons of economy the results obtained with the regular cycle are entirely adequate for the purposes.

The annealing cycle for malleable iron and pearlitic malleable iron is approximately as follows:—36 hrs. to soaking temperature (870 deg. C.); 40 hrs. at 870 deg. C.; 14 hrs. to 815 deg. C.; 14 hrs. to 760 deg. C.; 22 hrs. to 705 deg. C.; and 14 hrs. to 660 deg. C.

Pearlitic Malleable by Reheat Treatment

In the manufacture of Promal, a proprietary product, the white cast iron of any usual analysis is first completely graphitised by the annealing process best suited to its particular analysis. Following this the malleable iron is heat-treated in such a way as to produce a controlled amount of carbon recombination. The usual amount of carbon recombined is between 0.30 and 0.40 per cent. However, this can be varied above or below the amount so as to give varying physical properties.

In the production of Promal from malleable iron, both the temperature of heating and the time at that temperature are important factors controlling the amount of carbon recombination. While analysis variation has some effect on the temperature employed, this is not a critical factor, and rather wide variation in the normal elements of carbon, silicon, manganese, etc., can be handled by the same heat-treating cycle.

The physical properties of Promal as generally produced are as follow:—Yield point, 22 tons per sq. in., min.; tensile strength, 31 tons per sq. in., min.; elongation, 10 to 14 per cent. in 2 in.; fatigue strength, 15 tons per sq. in., min.; modulus of elasticity, 11,700 tons per sq. in.; Brinell hardness, 170 to 190 average; sp. gr., 7.35; coefficient of thermal expansion, 0.0000109; magnetic conductivity, 211 ohms per mil feet; and magnetic permeability, 79 at 200 amp. turns per in. By increasing the amount of carbon recombination, the tensile strength can be increased to 38 to 40 tons per sq. in. with increased yield point and Brinell hardness, but with a reduced elongation. By suitable alloy additions the tensile strength can be raised to over 45 tons per sq. in. with proportionately raised yield point and Brinell hardness, and with an elongation of 10 to 14 per cent. in 2 in. Promal can be produced also in the case-hardened form without otherwise changing its physical properties. A micrograph of Promal at 100 magnifications indicates that the carbon recombination has taken place about the graphite areas and at the grain boundaries of the ferrite grains.

Due to the quench and subsequent tempering, the iron-carbon alloy is probably in the sorbitic form. Variation of the tempering temperature can be utilised to produce different physical characteristics for any given combined carbon content. Promal, besides having high strength, also shows remarkable resistance to abrasive wear. This is probably due to the higher hardness envelope about the ferrite grains which protects the softer ferrite grains from attack by the abrasive. By the addition of suitable alloys, Promal can be produced with increased resistance to atmospheric and other mild corrosive attack. It can be hot-dip galvanised without appreciably altering the physical properties. Promal, besides its high physical properties, abrasive wear resistance and uniformity of product, has the great advantage that, by suitably varying the heat-treatment and analysis, it can be produced with any given set of physical properties within wide limits.

Promal serves in the manufacture of chain products, outlasting the malleable chain which, although low in hardness, had served the industry very well. The combination of added wear-value and added strength of Promal over malleable iron has been of considerable benefit in chain-driving problems. Generally speaking, chains divide themselves into two classes, namely, those used for the transmission of rotative power and those used for the conveyance of materials. The former type of drives usually operate at higher speeds, consequently the added wear value is of great advantage, and where chains are used for conveying purposes, such as drag chains which scrape, the added resistance to abrasive attack provides much longer life.

Spheroidised Pearlitic Malleable

Z*-Metal is a general trade name applied to products produced by several licensees. It does not cover a material of any definite set of physical properties, but includes in a general way, products varying quite widely, all made under the same process essentially. By the use of this process the properties can be varied definitely in accordance with the uses to which the finished product is to be put.

It is a white iron base material, usually made in the air furnace. The elements added to make the analysis properly abnormal to produce the properties desired can be added either in the furnace or by means of ladle addition. At the present time perhaps the largest percentage of the product is made by ladle additions, various plants having individual methods for accurately controlling the additions so that they will come within specification limits. Z-metal can also be melted in other types of furnaces successfully, its molten characteristics being the same as those of normal white iron.

The casting characteristics of Z-metal are so similar to those of normal white iron that normal malleable foundry practice and pattern equipment can be used in its production. As is the case with the general group of products that come under the classification of pearlitic malleable iron, Z-Metal derives its physical properties from the retention of combined carbon in the usually ferritic matrix of normal malleable iron, and on the physical condition of this combined carbon.

Generally speaking, the first part of the process for manufacturing Z-Metal is similar to that of the heat-treatment of malleable iron. The material must be raised to a high temperature for a sufficient length of time to decompose entirely the massive cementite particles that are present, with the resulting precipitation of part of the combined carbon in the form of nodules of graphite. At this point of the process the material is austenitic.

Austenite, it is generally believed, will retain varying amounts of carbon in combined form depending on the temperature. The materials, then, can be cooled from any temperature above the critical with the retention of a desired amount of combined carbon dependent on that temperature. Then it is cooled to a point below the generally accepted critical range of from 718 to 760 deg. C., the cooling rate being relatively unimportant due to the analysis.

Manganese has the property of reducing the sensitivity of the material to cooling rates, and to Z-Metal generally sufficient manganese is added so that close control can be obtained of the combined carbon in the products after quenching to ensure uniformity, regardless of type of equipment used and section and method of packing the castings. At this point of the process the material presents a metallographic structure comprised of a completely pearlitic matrix, in which are embedded nodules of graphitic carbon. As indicated previously, the percentage of this combined carbon can be varied over a wide range, dependent on the manganese content of the material, and the quenching temperatures. The castings are then reheated to a temperature just below the carbon combining temperature for sufficient time to spheroidise the cementite of the pearlite, either completely or to any point desired to obtain the final physical properties which are to be produced. The cementite of the pearlitic matrix breaks up into these tiny globules of cementite quite easily, and the presence of a higher manganese content retards any possible breakdown or precipitation of carbon at the temperatures used, so that sufficient time can be allowed for complete spheroidisation.

White iron of normal analysis, if put through this same cycle of heat-treatment, will be completely annealed and will contain no combined carbon. This is because of its lack of the proper retarding agent to retain the carbon in combined form. Complete precipitation of the combined carbon will occur before complete spheroidisation can be accomplished.

By the use of the principles described, and by the variation of manganese content, and treating time, a wide variation of physical properties can be accomplished with relative ease. Essentially, however, the basic metallographic structure of Z-Metal is spheroidised, the strength and hardness of the various grades depending principally on the number of spheroids of cementite present, the higher-strength materials, of course, having a very dense structure of spheroidite cementite. The following table shows the general range of physical properties that can be obtained by this method. These are by no means limiting physicals, as variations can be produced even outside this range for specific purposes.

M.S. Tons per sq. in.	Y.P. Tons per sq. in.	E. Per cent.	Brinell No.
31	22	16—18	179
36	25	12—14	191
40	27	9—11	207
45	31	6—8	217

This table shows that Z-Metal in the normal physical ranges presents a ductility equal to that of good malleable iron. This is due essentially

* Standard Specifications for Malleable Iron Castings (A 47-33), 1933 Book of A.S.T.M. Standards, Part I, p. 490.

*Pronouced Zee in the United States.

to the spheroidised structure and is a condition that cannot be accomplished with normal pearlitic malleable iron. It will also be noted that Z-Metal has a high yield point in relation to the tensile strength, and it is believed that this can be attributed to the strengthening effect of manganese on the ferrite plus the additional rigidity of the ferrite grains due to the presence of spheroidised cementite particles allowing these grains to deform sufficiently to produce good elongation, but at the same time resisting deformation to a point proportionately higher than the normal grains of ferrite as found in malleable iron. The machineability of Z-Metal is much better than that of cast steel of a lower hardness. It machines easily due to the spheroidised structure and the lubricating properties of the graphite inclusions. Z-Metal reacts quickly to heat-treatment above the critical range for increased hardness, due particularly to the ease in dissolving the spheroidised cementite in austenite, and its structure can be varied through the usual range of martensite, troostite or sorbite as effectively as medium carbon steel. These heat-treating processes, however, result in a larger proportion of loss of ductility than is usually found in steel. This property has proved valuable in the differential hardening of Z-Metal parts where surface hardening is desired, Z-Metal reacting much more satisfactorily to this type of treatment than do most of the normal ferrous products. The properties of Z-Metal can also be altered by the addition of various alloys such as copper and molybdenum, with a general improvement in physical properties, impact resistance and corrosion resistance.

In connection with Z-Metal, it is pertinent to point out that licensees of the process generally object to the use of the term "pearlitic malleable iron" in description of that product. Their contention is that the characteristic spheroidised structure is in itself not well described as pearlitic. While some high-strength malleable iron products are distinctly pearlitic in metallographic structure they feel that Z-Metal hardly falls in that same classification. Their opinion is that pearlitic malleable iron to foundrymen generally indicates under-annealed malleable iron. They point out that the spheroidised structure of Z-metal is not the result of a shortened annealing cycle resulting in incomplete graphitisation, but rather a structure intentionally produced in the heat-treatment of a product to definite physical properties. While the physical properties can be varied by treating time, complete graphitisation will not take place within reasonable time limits, so that under-annealing is not a fact as complete annealing cannot be readily accomplished due to analysis.

From another source not identified with the production of Z-metal, the following data have been secured relative to the analysis and physical properties of a *trade sample:* C, 1.36 per cent. after annealing; Mn, 0.80 per cent.; Si, 0.80 per cent.; Mo, 0.16 per cent.; S, 0.128 per cent.; P, 0.213 per cent., and Cu, nil. Physical properties include: Tensile strength, 34.5 tons per sq. in.; yield point, 22.5 tons per sq. in.; elongation in 2 in., 13.5 per cent.; and Brinell hardness number, 179.

Z-Metal is used for many applications utilising its particular physical characteristics, including such uses as: crankshafts and connecting rods, bearing caps, clutch discs, brake heads and drums, gears, housings, burner nozzles, chain links and sprockets, clamps, elevator buckets, guards and gears for lawn mowers, hammer heads, hinges, man-hole covers, wrenches, cast-iron pipe-line appliances, vises, rock drills, tractor treads, etc.

Bull's-Eye Pearlitic Malleable

Mallix, another proprietary product, is a pearlitic malleable iron, and advertising literature gives typical values for its tensile strength as 33 tons per sq. in. and its elongation as 5 per cent. It is obvious that by changing the graphitisation so as to make the bull's-eyes larger or smaller, iron of this type can be given different physical properties. If graphitisation were completed plainly the material would have approximately the physical properties of malleable iron. If it were left very incomplete the elongation might be 1 or 2 per cent. and the tensile strength as great as 40 or 43 tons per sq. in.

The Brinell hardness number of iron of average quality will be about 180 to 200. The fatigue limit is quite close to one-half the ultimate strength. This particular quality of iron is made for purposes requiring a combination of good strength and not too much elongation in order to secure rigidity. The same producer makes one other intentionally pearlitic iron, but since it falls into the intentionally rimming class it is practically impossible to summarise its tensile properties which would vary with the size and shape of the specimen.

Short Cycle Pearlitic Malleable

Pearlitic malleable Meehanite covers a range of compositions rather than a single one, and those, according to its producers, are varied to meet specific requirements in the finished product. The base material is a white iron which does not contain a graphitisation retardant such as manganese or chromium. Whiteness of the base iron is controlled definitely so that the casting contains traces of free graphite which might be termed colloidal graphite, and that condition of whiteness expedites the malleablising process. The material may be produced either in the cupola or in the air furnace, and for all practical purposes, the total combined carbon in the air furnace material will range from 2.4 to 2.6 per cent., and in the cupola material from 2.7 to 2.9 per cent. The remaining components in both types are approximately 1 per cent. silicon, 0.35 per cent. manganese, and under 0.15 per cent. phosphorus.

In general, pearlitic malleable Meehanite is subjected to one of the following heat-treatments, but they may be varied slightly according to conditions and properties required:—

Heat-Treatment No. 1.—Consists in heating the material to 925 deg. C., and holding for 24 hrs. Then it is cooled rapidly in still air to 730, and slowly cooled from 730 to 650 deg. C., in 24 hrs. After reaching the latter temperature, it is air-cooled to atmospheric temperature.

Heat-Treatment No. 2.—Comprises heating the pearlitic malleable iron to 950 deg. C.; holding for 24 hrs. and cooling rapidly in air.

Heat-Treatment No. 3.—Consists in heating to 950 deg. C.; holding for 24 hrs. and quenching in oil from that temperature. Then the material is tempered at various temperatures to obtain desired hardness.

Physical properties attained through the previously mentioned heat-treatments are given in the following table which includes pearlitic malleable Meehanite produced in both the air furnace and the cupola:—

Properties of Pearlitic Malleable Meehanite.

	Cupola.	Air furnace.
Heat-treatment No. 1—		
Tensile strength, tons per sq. in.	20—24	24—29
Yield point, tons per sq. in.	13—15	15—19
Elongation per cent. ..	6.0—10.0	10.0—15.0
Brinell hardness number	140—190	140—190
Heat-treatment No. 2—		
Tensile strength, tons per sq. in.	29—40	36—45
Yield point, tons per sq. in.	20—24	22—29
Elongation, per cent. ..	1.5—4.0	2.0—5.0
Brinell hardness number	200—240	210—250
Heat-treatment No. 3—		
Tensile strength, tons per sq. in.	36—45	40—54
Yield point, tons per sq. in.	22—27	29—36
Elongation, per cent. ..	1.0—2.0	1.0—2.0
Brinell hardness number	250—300	250—350

Nickel-Chromium Pearlitic Malleable

Jewell alloy is a nickel chromium alloy malleable iron of high physical strength, possessing heat and wear resistance. It is fine grained, polishes like nickel plate, and is supplied in the following grades:—

Grade.	M.S. Tons per sq. in.	Y.P. Tons per sq. in.	E. Per cent.	Brinell No.
S ..	27	19	24	130
42 ..	31	24	15	180
Jewell alloy	40	27	8	200
V ..	38	31	5	250

Jewell alloy is used very extensively for stoker parts and other applications where heat resistance is required, and is also used extensively where resistance to wear is an important factor.

Pearlitic Malleable Containing Primary Carbides

A producer of ferro-alloys has seen an industrial use for an alloy containing primary carbides. The idea is to produce a microstructure consisting of a hard constituent (cementite) to resist wear, embedded in a softer matrix (ferrite or pearlite) which will yield under high local pressure and thus assist in developing a good wearing surface, together with temper carbon to aid in lubrication. In effect the structure is similar to Babbitt metal except, of course, that the hardness of the various constituents are of a much higher order. As in the case of Babbitt, the optimum hardness of the matrix depends upon the material of the other wearing part and the accuracy of finish. In general, the iron should be considerably softer than the material against which it wears, so as to conform and develop a good surface during running in. So far, the wear resistance has been excellent in the case of cylinder liners, bearings and brake drums.

These castings may be prepared in two ways. In the first case, one uses a standard malleable mixture with either normal manganese or high manganese (that is, 0.95 per cent. if a pearlitic or spheroidised matrix is desired) and heat-treats the casting so that first stage graphitisation is incomplete and second stage graphitisation is either complete or stopped at a point where some free pearlite remains. In the second case the amount of free carbide is fixed by the addition, to the standard or modified malleable composition, of an alloy-forming carbide which is stable at the usual heat-treating temperatures. Small amounts of vanadium will accomplish this; and 0.10 per cent.. vanadium has been found sufficient for most purposes. The castings are then given a standard malleable anneal, where a ferrite matrix is desired, and some intermediate treatment, such as is usual for Z-Metal, etc., where pearlitic or spheroidised matrices are sought. The second method has proved so far the best. It may be difficult to control first stage graphitisation even by very careful heat-treatment; whereas, by the use of alloys, the amount of primary carbide is proportional to the added alloy and easily predetermined, and no problems of heat-treatment are introduced. In addition, the form and distribution of the free cementite is superior and the strength and ductility of the casting improved. In the first case, the carbides are arranged in a regular dendritic pattern, while in the second case they are well scattered and of rounded form.

The use of copper along with vanadium has also been suggested to replace 0.2 per cent. manganese. The following data on Z-Metal as usually made with an addition of 0.1 per cent. vanadium and 1 per cent. copper, respectively, were recorded:—

	Z-Metal.	Z-Metal + V.	Z-Metal + V and Cu.
M.S., tons per sq. in. ..	30.4	31.2	33.2
Y.P., tons per sq. in. ..	24.5	27.7	25.5
E., per cent.	3.5	3.5	4.5
Brinell No.	209	211	209

Suspended Arches for Combustion Chambers

LATEST SCIENTIFIC PRINCIPLES

For a number of years past the suspended arch, that is, independent refractory blocks hung from overhead steel girders, has been used in the construction of heating furnaces, soaking pits, and other furnace settings in the iron and steel industries. The great advantages as against the ordinary simple sprung arch are well known, including the fact that a flat arch or roof of any width can be constructed, merely dependent on the strength of the girders, while uniform heating results and each block is independent of its neighbours and therefore can be easily replaced.

An important advance in this field is the "Detred" arch, a production of M. H. Detrick Company, Limited, of London, being on the same lines as the pioneer standard "Detrick" suspended arches and walls, except that the refractory blocks are half the width. Instead of being plain, the four sides are now also made with horizontal corrugations or treads, having rows of alternate projections and recesses, which intermesh with those of the adjoining blocks, forming interlocking joints.

As before, the arch is constructed with overhead steel girders not exposed to heat, and there are suspended a series of cast-iron hanger bars, which in turn carry the vertical refractory blocks by means of a T-slot in the upper part and a small cast-iron insertion piece attached to the hanger bar. The size of an arch or roof of a combustion chamber of this kind is practically unlimited, as already indicated, and arches up to 30 ft. wide and 70 ft. long are in use. The only slight difference is that the new blocks are the same in alternative rows and different from those in the other alternate rows merely in the position of the corrugations which have to intermesh. As usual, also, the longitudinal joints in the arch can be straight or staggered by altering slightly the position of each row of blocks.

These "Detred" blocks, 5¼ in. long by 3 in. wide, have a number of advantages. In the first place the intermeshing corrugations give an absolutely air-tight and gas-tight joint between each block. Also any small pieces that become loose through cracking or spalling are held in place, thus increasing the life. Further, the blocks because of their lighter weight, can be lifted in one hand, which makes building easier and simpler. In addition they are interchangeable with the "Detrick" blocks which are 10½ in. long and 3 in. wide, so that when the latter wear out they can be replaced with two of the new blocks, and the same applies to the nose pieces.

One of the chief advantages, however, is that a vertical refractory block only half the size can be made of superior quality, due to the fact that in the course of manufacture, involving slow burning in a kiln at very high temperature, the smaller block is heated uniformly right to the centre giving a product much more resistant to cracking and spalling with corresponding longer life. On the same lines "Detred" blocks for suspended combustion chamber walls, either of the air-cooled or the insulated type, are available, interchangeable with the original construction of wider blocks.

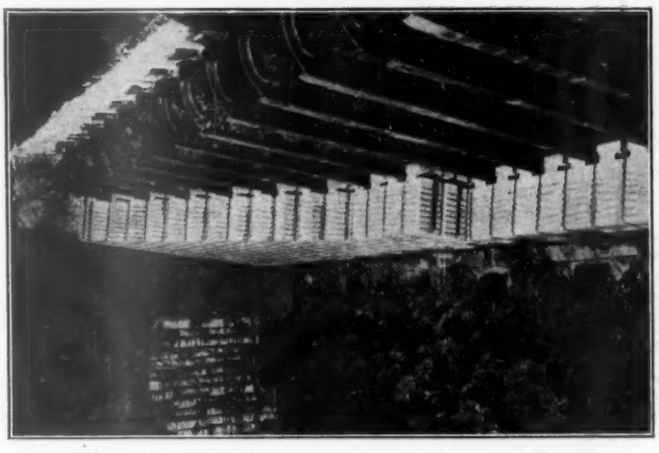


FIG. 1.—"DETRED" SUSPENDED ARCH IN COURSE OF ERECTION.

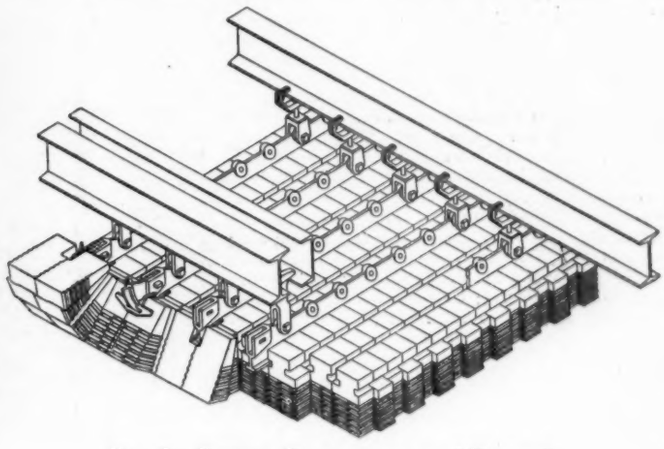


FIG. 2.—GENERAL CONSTRUCTION OF "DETRED."

Moulding Sands in Canada

A report on Natural Bonded Moulding Sands in Canada, by C. H. Freeman (Canadian Department of Mines, Report No. 767, 1936), states that production has declined from about 160,000 tons in 1922 to 8,000 tons in 1933, although during the last year or two there has been a slight increase. A fairly complete survey is given of the natural sand deposits throughout the Dominion, with a view to reviving the industry on a better organised basis, but it would seem that supplies of the best and most conveniently placed sands are becoming depleted, and large quantities, notably the well-known Albany sand, have had to be imported from the U.S.A. Here, too, the available supplies are rapidly declining, so that more attention must necessarily be directed to the question of synthetic moulding sands, both in the United States and in Canada.

The matter is of considerable importance to the North American engineering trades and all allied industries where sound and reliable castings are required. In view of the high standard now demanded in foundry work and the urgent and increasing need for flawless castings of all kinds, the question of suitable moulding sands—a factor of primary importance in efficient foundry work—becomes paramount. Also since there is growing evidence that synthetic sands are much more amenable to control and standardisation than many natural sands, interest in the synthetic product is rapidly growing. An essential constituent of synthetic moulding sands is a suitable clay bond, and in the U.S.A., and to a growing extent in Canada, it has been found that Bentonite is superior to other clay bonds. There are large supplies of Bentonite in Canada, and Mr. Freeman, on the authority of a previous report by Spence, issued several years ago, says that these supplies have not hitherto been worked in Canada. This does not, however, quite agree with the reported activities of Dominion Odolite Products, Limited, who have just established works at Hamilton and Winnipeg for treating Bentonite from deposits in the Penbina Hills.

The present report is mainly concerned with the supplies of natural bonded moulding sands, suitable for iron and non-ferrous castings, but, rather strangely, not including steel. One must infer, therefore, that sands suitable for steel castings must be imported or synthesised. A detailed and interesting account is given of the various modes of formation of natural sands, mainly concerning the economic geologist; also of the special characteristics required for foundry purposes, such as strength, permeability, etc.; methods of working and excavating; specifications, tests and testing apparatus. Suggestions for working and establishing the industry on a sound economic basis, due account being taken of suitable location, cost of transport, and co-operative working of several different deposits, so that the full advantages of blending may be achieved, are also dealt with. Mixing and blending require particular consideration, for if properly and skilfully carried out it is possible to obtain a wide variety of products suitable for an equally wide variety of needs, and closely approximating to standard specifications. Among the principal qualities or characteristics required are green and dry strength, permeability, refractoriness or fusion point, and size of grain. Most of these important qualities depend on the amount and nature of the clay bond which, in the ideal state—as in Bentonite bonded synthetic sands—is present in a minimum amount (5 to 8 per cent.), so as not to lower the fusion point, and forms a coating or film over each individual grain of sand.

The moulding sand industry of Canada has existed since the first foundry was established, and was originally in the hands of farmers. It gradually grew to be an independent and specialised industry in the hands of firms of contractors who might control several widely different types of supply so that, by proper blending, standardised brands could be produced. Standard methods of test were devised, partly in collaboration with the American Foundrymen's Association and other bodies. For a time there was a small export trade to the United States, but now more than half the moulding sand used in Canada is obtained from the U.S.A., together with small quantities from Great Britain and France.

International Congress of Electric Heat

MEETING AT SCHEVENINGEN

In conjunction with the convention of electricity producers and distributors held recently at Scheveningen, an international congress of electric heat was also convened, at which 22 Papers were read and discussed. Of this number several dealt with the application of electric heat in metallurgical practice, having reference to heat-treatment resistance furnaces, electric melting furnaces and coreless induction furnaces.

PROF. DR.-ING. F. KNOOPS discussed the potential development of electric heat for industrial applications in Europe. He estimated that in 1935 the total electric power generated in Europe was approximately 150,000 × 10 kw.-hrs., and pointed out that at the present time only about half of the available water power was being utilised. The harnessing of the water power still available would, it is calculated, permit an additional saving of 15,000,000 tons of coal, now used for electric power generation. The annual consumption of electric power in kw.-hrs. per head of population in various European countries varies considerably from one country to another, and is now at the following approximate levels:—Norway, 3,200; Switzerland, 1,320; Sweden, 850; Belgium, 500; Germany, 480; Great Britain, 450; Finland, 390; France, 380; Austria, 360; Holland, 280; Italy, 280; Czecho-Slovakia, 200, and Denmark, 190. The author also gave various figures for the power consumption in electric pig-iron manufacture and the costs of power for making ferro-alloys in the electric furnace and the manufacture of steel and grey castings.

A. G. ROBIETTE discussed the use of controlled atmospheres to prevent oxidation in metallurgical operations. The author also dealt with the use of decomposed ammonia for bright annealing, which was, however, uneconomic, particularly in large furnaces on continuous operation: this circumstance has led the author to evolve a cheaper and simpler process for preparing hydrocarbon gas, illuminating gas and coke-oven gas, using a combustion chamber, a condenser for removing the water, and a sulphur separator.

Radiation Furnaces

M. ETIENNE, reviewing the applications of the radiation-type furnace, gave details of a new design of furnace consisting essentially of a cylindrical furnace chamber with a graphite or amorphorus carbon rod along the longitudinal axis to act as the radiation element. This design avoids contact between the radiation element and the bath and produces convection currents in the metal by electromagnetic action. The overheating of the melt obtained in arc furnaces is entirely avoided. Losses due to burning are less than 2 per cent. in this furnace, while the furnace atmosphere can be made oxidising or reducing as required. A 300-kg. charge of Ni-Cr steel (20 per cent. of each Ni and Cr) has a consumption of only 240 kw.-hrs. With an electrode consumption of 620 gms., the consumption for a rustless 18/8 steel is 720 kw.-hrs. per ton.

Coreless Induction Furnaces

Coreless induction furnaces were dealt with by DR.-ING. N. A. HALBERTSMA and N. BROGLIO, who pointed out that the throughput of a furnace of this type depends not only on the capacity and charge of the crucible, but above all on the correct adaptation of the nature of the electric supply and the contents of the crucible. In Holland extensive researches have been made to determine the most economical and practicable conditions of supply, but little progress has been made in running two furnaces from a common supply, which would permit alternative operation. Halbertsma suggests that greater efficiency may be obtained by employing higher frequencies, in the case of a 300-kg. furnace between 10,000 and 1,000,000 cycles. This may prove satisfactory where the charge is in a pulverulent condition and melting can be initiated with sufficient speed in the peripheral zones. For this purpose he has evolved a valve generator for use in conjunction with furnaces, and which is already operating on a 300-kw. furnace. The use of valve or mechanical generators reduces in the end to a question of cost, although the valve type offers the advantage that the frequency can be carefully adapted to the size distribution of the charge with the minimum of trouble.

High-Frequency Furnaces

N. BROGLIO reviewed the evolution of high-frequency furnace technology in Germany during the last seven years. This period of development commenced in 1929 with the starting up of a 300-kg. furnace for continuous operation. The economic aspect of these furnaces has been given careful consideration, and every endeavour has been made to combine technical efficiency with economic operation. Two furnaces can now be run simultaneously from a single generator, although special care must be exercised in controlling the metallurgical conditions in the furnaces. The periodicity of furnaces up to a capacity of 300 kg. is between 100 and 2,000 cycles, and for the latest furnaces above 300 to 6,000 kg. capacity it is 500 cycles. The furnace voltage varies between 1,500 and 3,000 volts. From metallurgical considerations, less weight is placed in Germany on rapid melting and treatment than on the precision control of melting conditions, especially in the manufacture of high-grade forging and rolled steels. The speed of operation is greater in foundry practice and melting periods of 40 to 60 min. are readily obtainable. It is, however, advisable not to curtail these periods further, as otherwise the quality of the products will be adversely affected.

Iron and Steel Output

The British Iron and Steel Federation report that there were 110 furnaces in blast at the end of July, three having been blown in and five put out of operation during the month. The production of pig-iron in July amounted to 661,100 tons, compared with 644,100 tons in June and 547,300 tons in July, 1935: the month's production includes 144,700 tons of hematite, 386,600 tons of basic, 103,600 tons of foundry and 9,400 tons of forge pig iron. The production of steel ingots and castings in July amounted to 974,100 tons, compared with 965,900 tons in June, 1936, and 803,300 tons in July, 1935.

Company Meeting

The annual meeting of the Buell Combustion Company, Limited, was held last Monday, in London. MR. JOHN A. AGNEW (chairman), who presided, said that certain important factors had emerged from the year's working which would seem to show that the policy of extending the company's activities and organisation had been justified. The marked success which had attended the installation of every Buttner dryer must ultimately prove of appreciable value to the company, while the Van Tongeren system for dust precipitation had fully justified itself. The Micrometric Reduction Company, Limited, in which their company held an important interest, had acquired the world's rights—apart from the American Continent—of the "Micronizer" reduction system for the processing of materials other than coal and metalliferous ores, which latter rights were owned by the Buell Combustion Company. Two unique features of this system were its exceptionally strong patent position and its ability to reduce materials, without the aid of mechanically-moving parts, to a degree of fineness hitherto impossible of commercial achievement by any known means of pulverisation.

Dangers in Copper

By "ONLOOKER."

The trend of copper values has latterly been all one way, for, apart from a brief check when a 5 per cent. increase in production was announced, the quotation has moved steadily upwards until the export price at 9¾ cents c.i.f. reached the same level as the domestic price. It rather appeared, when the increase in output was made effective, that the time chosen for the alteration was not very fortunate, as buyers had recently covered well ahead. The setback was shortlived, and the publication of the July statistics showing a decline in world stocks of refined copper, and also some fall in production both in the U.S.A. and in other producing centres, confirmed the wisdom of this step. Now the stage seems to be set for a further advance in the American quotation, and at the present time there is every indication that 10 cents domestic cannot be long delayed. Demand for copper is undoubtedly excellent, and although this metal may have been given a better press than it deserves, there cannot be any doubt that consumption is on an excellent scale, and in some directions actually still on the increase. Copper has had its lean years, and is now enjoying the years of plenty.

Output and Price

The writer would be the last to suggest that copper at 9¾ cents, or even at 10 cents, is overpriced; the figure is a reasonable one, and by comparison with tin, for example, the metal is still cheap. Moreover, great credit is due to the associated producers for the capable manner in which the curtailment scheme has been operated to lift the market out of the slough of despond into which it had fallen, all the more so, perhaps, if we remember that there is a very large productive capacity at a cost of between 5 and 6 cents per lb. To-day, in spite of the rate of output being cut by 25 per cent., many copper mining companies are earning good profits, a fact to which the appreciation of share values on the stock exchanges in London and New York testifies, and there is probably a fairly strong body of opinion among the producers favouring a policy of increasing output still more. Attention has already been drawn to the fact that stocks are decreasing, and by the end of this year the statistical position ought to be good, but the decline must not be allowed to go too far, for there is always a fairly large "dead" stock in copper which is not immediately available in satisfaction of demand. Reserves of rough copper in official warehouses in the United Kingdom are down almost to a dangerously low level, and the stocks of refined are very much lower than they were a year ago. At the moment a wave of panicky buying by users might have disastrous results.

Incidence of the Speculator

In many ways copper is at the parting of the ways, and great care will have to be taken if the situation is not to get out of hand. The curtailment scheme is now beginning to have a very real effect on the markets on both sides of the Atlantic, and such a powerful weapon as interference with the natural laws of supply and demand obviously needs careful handling by experts. On these occasions the danger lies in the unknown factor of speculation. It is, of course, the duty of those in charge of the plan for keeping production down, to see that the speculator does not have an opportunity to magnify a price trend out of all reason, and on the present occasion the way to do this is to exercise a proper control over output in relation to demand. Stampeding consumers into buying is a mistake, and it is felt by many that the "twenty-four hours' notice" method used by the American sellers is all wrong.

Toughness of Cast Irons from Transverse Stress/Strain Curves*

By G. L. HARBACH

Introduction

This Paper is intended for the practical man rather than the technician. Therefore, technical terms and formulæ will be avoided as far as possible and consequently explanations may err on the side of simplicity.

Toughness is the term applied to a material which is not easily broken, and is generally associated with materials like steel which resist bending, twisting, hammering or shock. When compared with cast iron it may be considered as a property caused by the superior strength. In contrast to this there is the well recognised toughness of bronzes, which from the point of view of strength are close to cast irons but as far as toughness is concerned, they are comparable with steels, for they show marked resistance to bending, twisting, hammering and shock. From this, it is obvious that strength alone is not the deciding quality which makes a material tough.

Cast iron is generally considered a brittle material, but a man whose work it is to break pig-iron is in no doubt that there are different degrees of brittleness in different brands of pig-iron. He would readily place them in their order of toughness—a knowledge born of the effort he knows is required to break them. His list would not necessarily place them in order of tensile strength or analysis. A man who breaks up scrap castings will also have his mental list of the toughness of different mixtures, born of his knowledge of the effort required to break castings made from them. The order of this list will generally follow the strength values of the mixtures from which the castings were made except in such cases as the austenitic types of cast iron (Ni-Resist, etc.) which require much more effort to break them than castings made from an ordinary mixture, although the strength may be considerably lower.

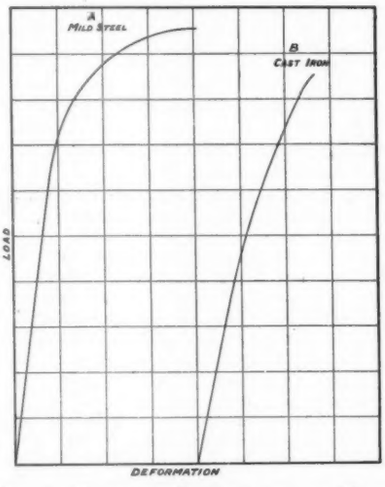


Fig. 1.—Relative Deformation of Mild Steel and Cast Iron under Load.

These anomalies are often mystifying to the thoughtful foundryman, and it is hoped that the consideration of the stress/strain curves which follow will help him to appreciate that the properties that cause the difficulty in breaking cast irons and pig-irons can be shown graphically.

* Paper presented on behalf of the Institute of British Foundrymen to the Association Technique de Fonderie and printed in their Bulletin.

Stress/Strain Curves

Stress/strain curves are graphic representations of how materials behave when loads are applied. All materials when subjected to a load will deform to some extent. If the material returns to its original dimensions when the load is removed, the deformation must have been elastic, but if it does not, part of the deformation is plastic or permanent.

Some materials behave elastically within certain limits of load, above which plastic set occurs and the deformation is then partly elastic and partly plastic. If the amount of load (or stress) is plotted against the amount of deformation (or strain) the first part of the line will be straight, and at the elastic limit, the line will become curved. Mild steel is an example, see curve A, Fig. 1, which was obtained from a beam test.

Other materials show both plastic and elastic deformation even at low loads and the proportion of plastic to elastic increases with increasing load. Therefore, there is no definite elastic limit and no straight line in the stress/strain curve. Cast iron is an example, see curve B, Fig. 1.

With materials which give a curve similar to mild steel, deformation is proportional to any load within the elastic limit so that if the extension of a tensile specimen at a given load be determined it may be accepted that twice the load would double the extension. Thus the extension of a specimen could be calculated for any load within the elastic limit. If it is imagined that the material could be stretched elastically to double its original length the same method of calculation can be used to determine the load required. This estimated load is Young's Modulus of Elasticity usually represented by "E."

Different materials have different E values as they do not all deform to the same extent. For example, a bronze will stretch about twice as much as steel for the same dimensions and load. Therefore, the E value for bronze is about half that of steel. It will be seen that if E is known for any material a designer can calculate the distortion to be expected for any load that may be applied.

Determination of E for Cast Iron

Cast iron is one of the materials in which both plastic and elastic deformation occur at low loads. Therefore, calculations for E cannot be made accurately from the total deformation shown under any load. However, the plastic and elastic components may be separated and when this is done the elastic stress/strain curve is found to be practically a straight line for cast iron, as in the case of steels, and this provides the necessary data to calculate E for cast iron.

The extension of the tension side of a bar when loaded transversely is comparable with the extension caused by direct loading in tension. The stress/strain curves for tensile and transverse are similar in shape and as the deflection in transverse is much greater than the extension in tension, the values obtained from the transverse test are more easily and accurately recorded. Thus the stress/strain curves obtained from the transverse test, give not only information on strength and deflection but also on the elasticity, plasticity, and as will be shown later, the toughness, which is not a function of any property alone but a combination of all three.

In a Paper[1] read in 1934, from which Fig. 2 is taken, Pearce described a method for separating the plastic and elastic components of the deflection in the transverse test. He suggested that the calculation of E for cast iron be standardised on the elastic deflection at breaking load. A further suggestion was the use of the energy of rupture—the work done to the point of fracture based—on the breaking load and the total deflection at fracture. The results shown demonstrated that the energy of rupture placed four different types of cast iron in their order of toughness as shown by practical experience and repeated impact test results. The method was recommended as setting up suitable criteria for the critical comparison of cast irons especially in view of the fact that by various methods—alloy additions, inoculation, etc.—cast irons were now being produced having wide differences in properties, particularly as regards strength and brittleness.

The following extract from the Paper[1] describes Pearce's method for separating the plastic and elastic components from the total deflection in transverse.

"Curve OA, Fig. 2, represents the usual type of relationship between load and deflection in transverse. If at a suitable small load, say 0.1 ton, the total deflection is noted and the load removed, a small deflection remaining, the permanent set for that load can be observed. If this be repeated for a gradually increasing load, the curve OB can be drawn connecting load and permanent set, as well as OA, connecting load and total deflection. The difference at each load between total deflection and permanent set is the elastic deflection for that load, and is shown by the curve OC.

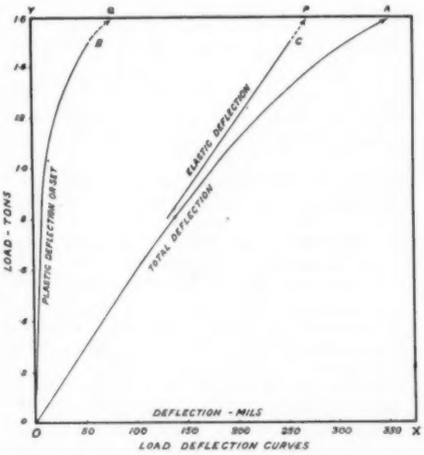


Fig. 2.—Elastic and Plastic Deformation of Cast Iron (Pearce).

The author has found that in the course of several hundred tests, for a wide variety of irons and shapes and sizes of bar, the line OC is generally straight. In a small number of cases the line bends slightly towards the deflection axis, but for practical purposes can be regarded as straight. A number of tests on tensile pieces with an extensometer taken in a similar way, show a similar slight curve, but further consideration of these results is deferred. The elastic deflection line does not always pass through the origin, but is usually close to it.

"The point of the arrow on the curve OA indicates the load and total deflection at fracture. The permanent set corresponding to the load at this point cannot, of course, be observed directly, but can be determined by a very simple construction.

"If C represents the last point obtained on the elastic deflection line OC, OC is continued to cut AY in P. If YP be regarded as the elastic deflection corresponding to the breaking load OY, then AP represents the permanent set. YQ is marked off equal to AP, and BQ

completes OB to represent OQ the load-set curve to fracture, just as OP represents the load/elastic deflection curve to fracture. If the iron breaks very close to the previous load and set reading, the construction is not necessary. It is not necessary to draw OA or OQ, for in most cases it suffices to draw the elastic deflection line OP, any point on which, of course, bears a linear relation to the applied load."

The information thus obtained gives the necessary data for the calculation of E, the formula for which is given in the appendix.

Comparative Test Results of Different Materials

The author has used the method recommended to examine his own cast iron mixtures, together with Ni-Tensyl cast iron, Ni-Resist cast iron and specially produced pearlite heavy duty pig-irons, made available by the courtesy of their respective manufacturers. Mild steel and hard phosphor bronze were also included to obtain representative curves of high and low tensile strength materials, both of which have well recognised toughness properties. Table I gives the chemical composition of the different materials.

Variations in diameter of a transverse test bar have marked effects on the deflections (for correction, see appendix); the foundry skin also tends to produce erratic results, so that for strict comparison all bars were cast 1.2 in. dia. (with the exception of sample No. 4, which was cast as a pig approximately 3 ft. long and 3 in. by 3 in. section, and the mild steel which was a 1¼ in. dia. bar) machined to 1.1 in. dia. and tested under standardised conditions. Readings were taken for total deflection and permanent set at each 0.1 ton from zero to breaking load. Table II shows the results obtained at each reading for two cast irons of contrasting strengths. Further reference to this table will be made later, when considering the results after plotting as curves. Table III gives the data obtained from the transverse tests, together with the tensile strengths and Brinell hardness numbers. The plastic deflections at breaking load are shown both as readings and as percentages of the total deflections. The percentages have been included, as the proportion of set is more important than the actual amount of set, in deciding the shape of the curve. This is most marked if Samples 1 and 4, having high and low total deflections, but high proportions of set, are compared with Sample 3 having a medium total deflection and a low proportion of set (see Fig. 3).

The Stress/Strain Curves

Fig. 3 shows the total deflection curves, and the plastic and elastic deflections, having been separated, are shown in Figs. 4 and 5. Each set of curves has been plotted from a single origin to make comparison easy. In examining Fig. 3 the most outstanding feature is the marked bend in the curves for mild steel and bronze at loads above their yield points. Both having been loaded to maximum stress and not breaking load, the downward and much longer curves corresponding to the elongation in the tensile test are not shown. The Ni-Resist being slightly ductile shows the most marked bend in the iron series and this corresponds to the small amount of elongation recorded in the tensile test. The most distinct bends in the iron curves, with the exception of Ni-Resist, occur with the high-strength Ni-Tensyl and the special pig-iron. All three irons mentioned are difficult to break and have good toughness properties.

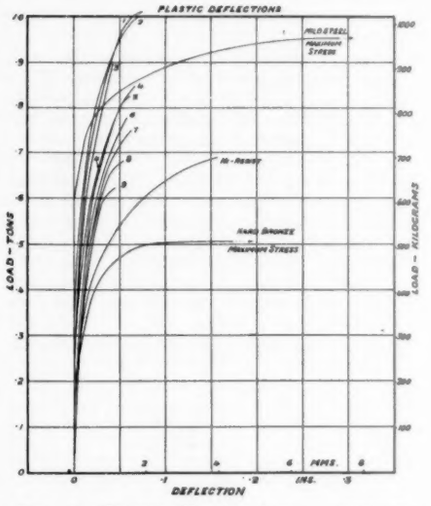


FIG. 3.—PLASTIC DEFLECTIONS OF VARIOUS ALLOYS UNDER INCREASING LOADS.

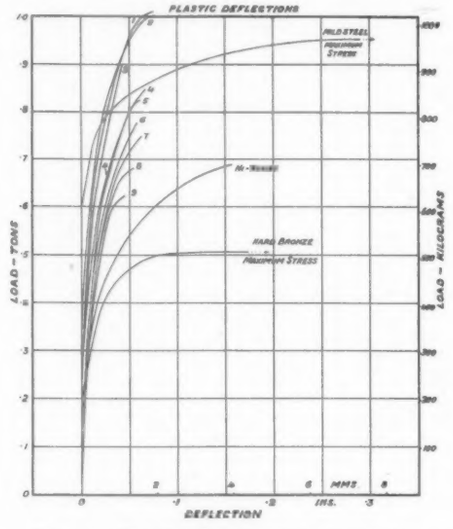


FIG. 4.—PLASTIC DEFLECTIONS OF VARIOUS ALLOYS UNDER LOAD.

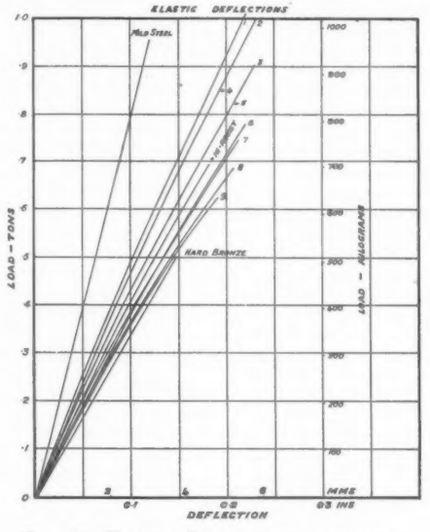


FIG. 5.—ELASTIC DEFLECTIONS OF VARIOUS ALLOYS UNDER INCREASING LOADS.

The remainder of the curves are roughly parallel but of varying length according to the breaking loads. As the elastic curves are practically straight lines (see Fig. 5) it follows that all, or nearly all, the bend in the total curves must be due to plastic set and this is shown quite distinctly in Fig. 4. Practical experience of the properties of the different materials and the information supplied by the curves suggest the conclusion that materials which are difficult to break produce stress/strain curves with a distinct bend when approaching the maximum load. This is associated with the property of plasticity and indicates that to some extent toughness is dependent on this property. Further consideration of Fig. 4 shows that with the apparatus used no plastic set occurs in mild steel or bronze at loads below the yield point but cast irons show small amounts of set at low loads.

In strong irons the set is too small to measure at the smallest load used in the tests (0.1 ton) and increases slowly up to nearly breaking load, then rapidly, giving the bend previously noted. In weak irons set occurs at low loads and increases rapidly up to breaking load, although the total set in a weak iron does not as a rule exceed that of a strong iron (see Table III). The difference in development of set has a definite effect on the shape of the curve. Table II and the curves for these irons illustrate this point very well. A further point of interest in Table II is the increasing difference in elastic deflections shown by the weak iron, when nearing breaking load, which results in a definite bending of the elastic curve. As a pronounced bend in the elastic curve is probably associated with large graphite flakes in the iron, such a result is to be expected with an iron of the type of Sample 9.

E Values Compared

Reference to Table III shows that the total, elastic and plastic deflections all fall roughly as the strength decreases, but the range is less for the deflections than for the breaking loads—from sample 1 to 9 the load drop is 38 per cent., but the total deflection only falls 19 per cent. and the elastic only 12½ per cent. If the strength were raised without altering the deflection the effect would be to bring the curve closer to a vertical line (thus raising the E value) and this is what happens to some extent by the load varying over a wider range than either the total or elastic deflections, with the result that E values rise as the strength rises (see Fig. 5 and Table IV).

From Fig. 5 it will be seen that mild steel has the least elastic deflection of the series; bronze has over twice as much for all loads comparable with the steel, and cast irons are between the bronze and the steel, the strongest iron being about 70 per cent. more than the

TABLE I.—*Composition of Samples Used.*

Material.	Sample mark.	T.C.	Si.	Mn.	S.	P.	Ni.	Cu.	Cr.
Mild steel	M.S.	0.20	0.023	0.68	0.037	0.037	—	—	—
"Ni-Tensyl"	1	2.72	1.68	0.44	0.081	0.068	0.79	—	—
High test cast iron ..	2	3.13	1.73	0.95	0.093	0.26	—	—	—
Nickel cast iron	3	3.45	1.61	0.62	0.113	0.52	0.90	0.52	0.25
Special pig-iron	4	2.90	1.74	0.87	0.141	0.19	—	—	—
Cast iron	5	3.44	1.55	0.66	0.055	0.59	—	—	—
" "	6	3.50	1.64	0.68	0.125	0.68	—	—	—
" "	7	3.47	1.78	0.80	0.096	0.67	—	—	—
" "	8	3.41	1.89	0.78	0.086	0.72	—	—	—
Soft cast iron	9	3.35	2.61	0.74	0.074	1.04	—	—	—
"Ni-Resist"	10	2.30	1.92	0.64	0.093	0.21	15.05	6.45	1.88
Hard bronze	P.B.	—	—	—	—	0.09	—	86.67	Sn. 12.90

steel. The slope of the elastic lines show, therefore, that the E value for bronze is about half that of steel; weak irons have E values close to bronze and strong irons about two-thirds that of steel. The actual E values are shown in Table IV. The E values obtained from the total deflections are included as they will compare with works test results which follow later, also, by the difference from the true E values they serve as a measure of plastic set.

American practice is to calculate E values from the total deflection at a quarter of breaking load as this may be taken as representing a probable working stress. For this series of tests 0.2 ton was taken throughout as approximately a quarter of breaking load and the E values obtained are included in Table IV. It will be seen that they follow the same order as the true E values and in the main are rather higher but the variations are not constant. Whilst it may be considered that such readings are representative of the results under working conditions the present work indicates they are not a reliable guide for the following three reasons:—

(1) The amount of deflection is so small as to make accurate measurement difficult, particularly as it is the only reading taken before fracture and therefore cannot be checked by succeeding readings.

(2) The deflection is made up of the two components, elastic deflection and plastic set in unknown proportions.

(3) The slope of the curve produced is only a poor guide to the shape of the total curve.

Moreover, if a standard method is adopted for calculating E values, the use of the elastic deflection at fracture is more likely to give comparable data between different investigators than that obtained from an arbitrary deflection reading taken below breaking load.

Table IV includes the values obtained by dividing the breaking load by the total deflection. This gives the same result as E from the total deflection without using the factors which take into consideration the dimensions of the test bar. Such results are only useful in determining the average slope of the curves of standard sizes of bars for purposes of comparison and the method is not recommended as an alternative to the calculation of E values.

TABLE II.—*Deflections Compared. Results in Mils.* (0.001-in. = 1 mil.).

Load. Tons.	Weak iron.			Strong iron.		
	Total.	Elastic.	Plastic.	Total.	Elastic.	Plastic.
0.1	30	28	2	22	22	0
0.2	59	55	4	41	40	1
0.3	90	82	8	63	60	3
0.4	122	109	13	86	81	5
0.5	161	141	20	109	102	7
0.6	213	180	33	135	125	10
0.625	238	At breaking load.		—	—	—
0.7	—	—	—	165	149	16
0·8	—	—	—	198	172	26
0.9	—	—	—	238	195	43
1.0	—	—	—	282	219	63
1.015	—	—	—	295	At breaking load.	

Toughness and Areas Under Stress/Strain Curves

As the areas under stress/strain curves are always roughly triangles, $\frac{\text{load} \times \text{deflection}}{2}$ will give approximate results. This calculation is satisfactory for determining the area under the elastic curve, as the line is practically straight, but for the total deflection curves it is always lower than the actual, and the error varies according to the amount of bend in the curve. A comparison of Ni-Resist with Sample 9 in Table IV (areas) will illustrate this point. The areas under the total deflection curves in this table were measured by planimeter; those for the elastic curves were calculated as triangles and the areas under the plastic curves taken by difference.

The area under a stress/strain curve is generally accepted as representing the energy used in causing fracture or deformation, but practical experience shows that irons which produce areas not widely different may require widely different amounts of energy to break them. The ratio of the areas of Sample 9 and Ni-Tensyl (Table IV) is 1:2, but castings up to 1 in. thick from iron No. 9 can be broken with a sledge hammer, whilst castings of similar section from Ni-Tensyl often require several blows of a 1-ton breaking ball.

Taking the experience of breaking pig-iron as a further example—the ratio of areas under the stress/strain curves for a series of pigs, from common low strength irons to high quality irons of the cold-blast type, would probably be no greater than 1:3, but the number of hammer blows or drops from a constant height on to a pig breaker, necessary to cause fracture of pigs of the same size, would be far more than that ratio. Hurst demonstrated the same property by preparing two sets of ring test pieces, both sets having the same modulus of rupture, but one set showing a stress/strain curve characteristically tough and having a greater area than the other, and asking members of an audience to break one of each and say which is the stronger. Invariably the ring showing the good curve was selected as the stronger of the two, although test results indicated the strength to be the same and the difference in areas did probably not exceed 20 per cent. Obviously to distinguish a marked difference when broken by hand, the difference in effort required must be greater than indicated by the areas. It might be argued that the information from transverse test stress/strain curves, with a load applied slowly, is not necessarily an indication of the resistance of a material to hammer blows or shock, but it must be admitted that breaking a ring by hand produces a stress of similar type to that of the standard ring test. At present there is no test which accurately measures the effort required to fracture cast iron, and one has to be content with the knowledge gained from test results which experience has shown are associated with other properties, and which enable one to place a series of irons in their correct order of toughness, as in the case of the ring tests. The shape of the stress/strain curve is extremely informative in this respect.

Repeated Impact Results

The British Cast Iron Research Association use an impact test of the repeated blow type on a bar 15 mm. dia. by 165 mm. long, the energy of each blow being 0.48 ft.-lb. The testing conditions were established to give the most critical results. This was done so as to avoid the two extremes of too short a test, approaching a single blow test, and too long a test, approaching a fatigue test. Thus, in practice, small differences in structure may cause wide differences in the number of blows before fracture (making duplicate tests desirable), but in the main there is no doubt that the repeated impact test results place irons in the same order as practical experience based on the effort required to break them.

If the repeated impact results of samples 1 to 9 in Table IV are examined it will be seen they follow the same order as the strengths and areas under the total deflection curves with the exceptions of Samples 3 and 6. In both these cases the E value and the areas under the plastic curves are below that expected from their positions in the series on a strength basis. This brings the question back to a consideration of the type of curve associated with materials of known toughness—mild steel and bronze. Both curves start as straight lines and develop pronounced bends from the elastic limit to the maximum stress; mild steel with the higher strength and E value has the greater toughness of the two.

From this it may be expected that cast irons which give curves having similar characteristics—little plastic set at low loads, high plastic set at breaking load, with high strength and good E value—to have the best toughness Ni-Tensyl most nearly complies with these conditions and gives the best impact results of the series. Below this, good results may be expected from iron of lower strength but with the remaining characteristics well pronounced, as in bronze. Ni-Resist complies with these conditions and gives the next best impact results.

TABLE III.—*Test Results: Transverse Bars Cast 1.2 in. dia., Machined to 1.1 in. dia., Tested at 18 in. Span.*

Sample.	Transverse.							Tensile.		
	Breaking load. Tons.	Rupture stress. Tons per sq. in.	Deflection in mils. (0.001 in. = 1 mil.).				Plastic per cent. of total.	Tons per sq. in.	E per cent.	Brinell No.
			At 0.2 ton.	Total.	Elastic.	Plastic.				
M.S.*	0.953	32.7	26	408	122	286	70.1	28.9	40	143
1	1.015	34.9	41	295	220	75	25.4	19.2	—	269
2	1.00	34.4	43	300	231	69	23.0	18.4	—	255
3	0.90	30.9	46	271	229	42	15.5	17.2	—	269
4†	0.85	29.2	42	257	190	67	26.1	15.2	—	228
5	0.83	28.5	49	266	206	60	22.6	15.0	—	228
6	0.78	26.8	56	279	220	59	21.1	14.0	—	228
7	0.75	25.8	52	278	215	63	22.7	12.8	—	217
8	0.684	23.5	53	260	208	52	20.0	12.2	—	223
9	0.625	21.5	59	238	192	46	19·3	12.0	—	217
10	0.695	23.9	50	338	181	157	46.5	10.0	1.0	156
P.B.*	0.502	17.3	60	320	145	175	54.7	14.4	2.0	107

* Transverse results at maximum stress not breaking load. † Machined from pig.

Incidentally over 7,000 blows have been recorded on high strength Ni-Resist and up to 2,500 on high strength Ni-Tensyl of the inoculated type (see Table V). This suggests that for good toughness, high plastic set at breaking load is more important than high strength—a point which confirms the conclusion of Pearce' "Brittle irons have a low permanent set and tough irons a high permanent set" and is borne out by further examination of Table IV. Comparing Sample 2 with Ni-Tensyl, the loads, deflections and areas are all close but the curves show that, whereas the bend in the Ni-Tensyl curve is mainly at breaking load, the other bends from the start and shows no pronounced

bend at breaking load. The curves for Samples 4, 5 and 7 are all similar in shape to Ni-Tensyl, and are associated with good impact results, whilst those for Samples 3 and 6 are similar to No. 2 and the impact results are comparatively low. Sample No. 4 with a good curve in all respects shows up well, considering the impact test bars were 15 mm. dia. from the centre of a pig. The same iron remelted and cast into test bars gave up to 1,000 blows before fracture and although stress/strain curves were not plotted, the results indicate confirmation of the hereditary properties of this type of iron, dealt with by Hurst.[2] Samples 3 and 6, both with total areas similar to their neighbours, but with low proportions under the plastic curves and comparatively low E values, gave low impact results for their respective positions, and we thus have instances of weaker irons (Samples 5 and 7) with good curves being more difficult to break than the stronger irons (Samples 3 and 6) with poor curves. In the case of No. 6 it is worth noting from Table III that it shows a high deflection at quarter load and Fig. 3 shows that it continues high up to about half load when it crosses the curve for iron No. 7 and proceeds to breaking load without a pronounced bend. It was possible, by considering the test data and curves of these two irons to forecast the relative impact results before the impact tests were carried out.

Sample 8 with a good shaped curve gives impact results close to iron 6, but Sample 9, although the curve is of good shape, is low in strength and deflection causing the areas to be small, and low impact results were to be expected.

Fig. 6 summarises the results shown in Tables III and IV, in a series of curves.

TABLE IV.—*Mechanical Properties of Various Alloys.*

Sample.	E values in millions of lbs. per sq. in. from various deflections.			Ratio of Breaking load to total deflection.	One half load × Deflection.	Areas under curves, in.-tons.			Repeated impact. Number of blows.
	Elastic.	Total.	At ¼ load.			Total.	Elastic.	Plastic.	
M.S.	29.7	—	29.2	—	0.194	—	0.058	—	Not broken.
1	17.5	13.1	18.5	3.44	0.150	0.177	0.111	0.066	1,860
									1,039
2	16.4	12.7	17.7	3.33	0.150	0.178	0.115	0.063	326
									395
3	14.9	12.6	16.5	3.32	0.122	0.135	0.103	0.032	258
									264
4	17.0	12.5	18.1	3.30	0.109	0.128	0.081	0.047	230
									333
5	15.3	11.8	15.5	3.12	0.111	0.125	0.085	0.040	278
									263
6	13.5	10.6	13.6	2.79	0.109	0.123	0.086	0.037	140
									114
7	13.2	10.3	14.6	2.70	0.104	0.123	0.080	0.043	155
									191
8	12.5	10.0	14.3	2.67	0.090	0.105	0.072	0.033	122
									91
9	12.4	10.0	12.9	2.60	0.074	0.087	0.060	0.027	25
									27
10	14.6	7.8	15.2	2.06	0.117	0.155	0.063	0.092	617
									432
P.B.	13.1	—	12.7	—	—	—	0.072	—	5,942
									3,636

Works Tests and Research Results Compared

Table V gives the average of works tests results in groups of various strengths, for the same range of irons as the research results shown in Tables III and IV. The loads and deflections are not quite comparable between the two sets of results as the works results have all been corrected for errors in size and therefore are for the standard 1.2 in. dia. bar and not 1.1 in. dia. The smaller diameter naturally increases the deflection and lowers the breaking load. Whilst repeated loading has little, if any, effect on the breaking load and total deflection, two different machines were used for the two series of tests, each having different methods of gripping and load application, so that the differences in deflections in Tables III and V may not be entirely due to the effects of machined bars of smaller diameter. On the whole the deflection readings of the research results appear somewhat high and the E values are consequently low, but any differences due to the machines or methods of testing do not interfere with comparisons between results in the same series of tests.

It will be seen that the general trend of the results in Table V is the same as in Table III —the breaking loads vary over a wider range than the deflections which causes the E values (calculated from the total deflections) to rise as the strength increases. If allowance be made for plastic set in the same proportions as shown in Table III, the E values based on elastic deflections vary between 22,000,000 and 15,000,000 lbs. sq. in. for irons between 25 and 10 tons tensile strength which agrees with the results of other investigators.[1, 2, 3] An examination of some hundreds of works results indicates that when the ratio of span to diameter is close to 15:1, the E values based on total deflections from different sizes of bars is fairly constant, but decreasing span or increasing diameter results in more deflection than that given by theoretical calculation, thus lowering the E value.

Two types of Ni-Resist are included in Table V to illustrate the wide variation of properties obtainable in this material by adjustment of composition, melting methods, etc. In both cases the deflection is about 50 per cent. over that of an ordinary cast iron of similar strength and the plastic set amounts to approximately half the total deflection. All types of Ni-Resist are noted for toughness and castings in the type which gave 7,000 blows impact are as difficult to break as bronze castings.

The areas under the curves for different groups increase as the strength increases, but, although the areas in each group are similar, the shapes of the curves vary, so that it is to be expected that the repeated impact results as a whole rise as the strength rises, but vary widely in each group. Variations in structure also have a scattering effect on the results due to the testing conditions previously explained.

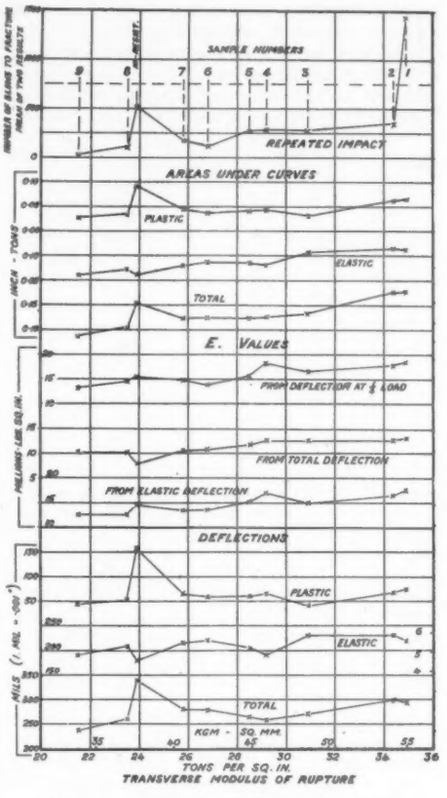


FIG. 6.—SUMMARY OF RESULTS FROM TABLES III AND IV.

Conclusion

Cast irons have no definite elastic limit and therefore there are no straight lines in the stress/strain curves. If the plastic and elastic components are separated, the elastic portions are practically straight lines and may be used to determine the E values. In general the E value for cast iron increases with increasing strength.

Practical experience of materials shows that toughness is associated with certain characteristics in the stress/strain curves and when similar characteristics are produced by cast irons they are also associated with good toughness. Cast irons having a low proportion of plastic set are brittle whilst those having a high proportion tend to be tough. Irons in which the major portion of plastic set occurs near the breaking load are tougher than irons of otherwise similar strengths and deflections. The proportion of plastic set varies roughly with the strength and

TABLE V.—*Average Results of Works Tests. Bars 1.2 in. dia. at 18 in. span, Tested as Cast.*

Tensile range. Tons per sq. in.	No. of tests.	Load. Tons.	Deflection, in.	Trans. M. of R. Tons per sq. in.	Tensile tons per sq. in.	Elong. Per cent.	E from total deflection, lb. per sq. in. × 10^{-6}.	Repeated impacts range.
24	1	1.475	0.234	39.1	24.1	—	16.9	2,506
20—23	6	1.48	0.238	39.2	22.4	—	16.7	500—2,500
16—20	7	1.205	0.230	31.9	18.0	—	14.2	250—1,000
14—16	12	1.075	0.220	28.5	14.9	—	13.1	100— 400
12—14	8	0.98	0.198	25.9	13.2	—	13.5	80— 200
9—11	3	0.822	0.178	21.8	10.0	—	12.4	10— 50
Ni-Resist ..	6	1.07	0.330	28.3	10.9	1.5	8.7	400—1,000
High strength Ni-Resist ..	2	0.804*	0.210*	36.7	15.2	2.0	10.7	2,500—7,100

* Tests made on bars 0.875 in. dia. at 12 in. span.

amounts to between 15 and 25 per cent. of the total deflection, except in such cases as Ni-Resist when the proportion may be 50 per cent. or more. When two irons of similar strength require different amounts of effort to break them it is found that the stress/strain curves are dissimilar, either in E value, proportion of set or the period in the loading when most plasticity develops. Experience shows that toughness is associated with curves which start at a sharp angle (good E value) and continue almost straight (little plastic set) until nearly breaking load when a pronounced bend develops (good plastic set).

Ni-Resist cast irons have a greater proportion of plastic set than ordinary cast irons and are invariably more difficult to break. When they are associated with fairly high strength and good E values, they are as difficult to break as bronze. From this and the results previously reviewed, it may be accepted that a good capacity for plastic deformation coupled with other favourable factors, offsets the effect of comparatively low strength and that toughness is not necessarily related to strength.

It is suggested that transverse test stress/strain curves are particularly informative regarding the properties of the different types of cast irons now available, and that the study of them will do much to explain such apparent anomalies as cold-blast irons being tougher than hot-blast irons of similar strength, and the toughness of austenitic irons, despite their comparatively low strength.

In conclusion the author wishes to thank Mr. J. T. Graham, Director (Manufacture and Engineering), Messrs. Worthington-Simpson, Limited, Newark, for permission to use the test results referred to in this Paper, Mr. J. E. Hurst and Mr. J. G. Pearce for their assistance during its preparation; the manufacturers who kindly supplied test bars of special irons and Dr. Bowen and Mr. Dickenson, respectively, Principal and Head of the Engineering Department, Newark Technical College, for placing the College testing machine at the disposal of the Author for the research tests.

REFERENCES.

[1] Pearce, J. G., Journal, Iron and Steel Institute, No. 1, 1934, p. 331.
[2] Hurst, J. E., FOUNDRY TRADE JOURNAL, February 21, 1935, January 30, 1936.
[3] "A.S.T.M. Symposium on Cast Iron," 1933, p. 68.

APPENDIX

The modulus of elasticity from the tensile test.

$$E = \frac{WL}{CA}$$

where E = modulus of elasticity,
W = load,
L = gauge length,
C = change of gauge length under load W, and
A = cross-sectional area.

The modulus of elasticity from the transverse test.

$$E = \frac{WL^3}{48DI}$$

where E = modulus of elasticity,
W = load,
L = span,
D = deflection at load W, and
I = moment of inertia.

The moment of inertia for a round bar is : $\frac{\pi d^4}{64}$

where d = the diameter.

For bars of standard dimensions $\frac{L^3}{48}$ can be calculated and used as a constant. Since breaking load and deflection vary with changes in diameter, both must be corrected to standard size, before the constant can be used. The breaking load varies as dia.[2] and the deflection inversely as dia.[4], so that when the breaking load has been corrected, most of the error in deflection has also been corrected, the remainder being calculated as follows :—

Corrected deflection = $\frac{\text{Actual deflection} \times \text{actual diameter}}{\text{standard diameter}}$.

The transverse rupture stress or transverse modulus of rupture is calculated from a formula which

(*Concluded in next column.*)

International Foundry Congress

DÜSSELDORF, SEPTEMBER 16 TO 20

We have now received from Dr. Geilenkirchen further details of the programme arranged for the entertainment and enlightenment of the delegates. These details are set out below chronologically.

Wednesday, September 16

Afternoon.—(1) River trip to Duisburg-Ruhrort Harbour, the largest inland harbour on the Continent of Europe. Here either the visitors can inspect the harbour or visit one of two works. These works are the Deutsche Eisenwerke Abt. Hüttenbetrieb, Meiderich, which is a roll and ingot mould foundry, also making large engineering castings, and the Eisenwerk Wanheim G.m.b.H., a large engineering foundry, possessing imposing machine, forge and erecting shops.

(2) Fried. Krupp A.-G., of Essen-Ruhr, whose works are world famous.

Thursday, September 17

Morning.—Official opening of the Congress and Exhibition.

Friday, September 18

Morning.—Technical sessions.

Afternoon.—The following works will be open for inspection :—

(1) Deutsche Eisenwerke, Abt. Schalker Verein, Gelsenkirchen. The works possesses a modern blast-furnace plant, and large foundries for the manufacture of high pressure pipes, rainwater goods and engineers' castings.

(2) Gutehoffnungshütte, Oberhausen. Here an attempt will be made to give a comprehensive appreciation of the interconnection of the coal, iron and engineering industries. After descending 2,000 ft. into the mine, a lecture, illustrated by cinematographic pictures, will be given.

(3) Yale & Town Manufacturing Company, Velbert. This concern possesses large grey iron, malleable and non-ferrous foundries. It is the largest lock factory on the Continent.

(4) Aug. Engels, Velbert. This is a large grey iron and malleable foundry.

(5) International Harvester Company, Neuss. This large agricultural implement works possesses a grey iron and malleable foundry.

(6) Humbolt - Deutz - Motoren A.-G., Köln-Deutz. This well-known concern manufactures both large and small engines, and is specially noted for its Diesel engine production.

Saturday, September 19

Morning.—Technical sessions.

Afternoon.—Visit to the Kaiser Wilhelm Cast Iron Research Institute.

Sunday, September 20

Morning.—Technical sessions.

Monday, September 21

Afternoon.—Visit to the Foundry Exhibition.

Tuesday, September 22

On this day a tour through Germany starts. It finishes on October 7, and during its course the following plants have kindly opened the shops for inspection :—*Buderus'sche Eisenwerke, Wetzlar.* (1) Sophienhütte, Wetzlar (blast-furnace plant). (2) Main-Weserhütte in Lollar (radiators and boilers). (3) Ludwigshütte bei Biedenkopf (builders' castings, stove grates and jobbing foundry). (4) Amalienhütte bei Laasphe (stove grates and jobbing foundries).

An alternative trip starting on Wednesday, September 23 will include the following industrial establishments—*Jünkerather Gewerkschaft, Jünkerath.* This foundry was established in 1687. It makes heavy machinery castings for metallurgical plant and rolling mills. Visitors to the plant will pass the Nürburgring, the semi-natural racing track wonder through a volcanic region. *Heinrich Lanz, Mannheim.* Agricultural implement manufacturers; quantity production of tractors. This firm saw the original creation of the Lanz-Perlit process. *Badische Maschinenfabrik, Durlach.* The largest foundry equipment works in Germany, possessing its own foundry. *Maschinenfabrik Esslingen, Esslingen.* Heavy machinery, locomotives, motor vehicle castings, specialising in automobile cylinders *Maschinenfabrik Augsberg-Nürnberg, Nürnberg.* Heavy machinery castings, particularly steam turbines.

Negotiations are still in progress for additional works visits.

TECHNICAL SESSIONS

On page 59 of our July 23 issue we detailed the Papers to be presented. The sessions at which they will be given are as follow :—Friday morning, September 18: Papers numbered 1, 2, 3, 4, and 10, at Session A and 5, 6, 7, 8, and 9 at Session B.

Saturday, September 19

Morning.—Papers numbered 20, 21, and 22 at Session A and 24 to 30 at Session B.

Sunday, September 20

Morning.—Papers numbered 11 (Mr. J. G. Pearce) to 15 at Session A and 17, 18, 19, and 23 at Session B.

(*Concluded from previous column.*)

takes into consideration all the dimensions of a test bar and gives the breaking load in the same terms as the tensile test, thus bringing the results of all sizes and shapes of bars to a comparable basis.

Transverse rupture stress for round bars.

$$f = \frac{WL}{4Z}$$

where f = rupture stress,
W = load,
L = span, and
Z = modulus of section.

The modulus of section for a round bar is $\frac{\pi d^3}{32}$

where d = diameter.

New Indian Steelworks

BENGAL IRON MERGER

Approval has been given by the respective boards of the scheme for the amalgamation of the Bengal Iron Company with the Indian Iron & Steel Company. The directors of the Bengal Iron Company state that negotiations have reached an advanced stage for the formation of a company to erect a new steelworks with an initial production of over 250,000 tons of steel ingots per annum on a site adjoining the Indian Iron & Steel Company's present blast-furnace plant at Hirapur. The amalgamation is a further step in the rationalisation of the Indian iron and steel industry.

The financing of the new company has, subject to the final completion of the negotiations, been undertaken by the Tata Iron & Steel Company, Burn & Company, the Indian Iron & Steel Company, Bird & Company, and Haes & Sons. Shareholders of the Tata Iron & Steel Company and of the amalgamated iron companies will be given preferential allotments.

In view of the progress of negotiations, it has been decided to postpone the annual meeting of the Bengal Iron Company in order to obtain the directions of the Court for the holding of the necessary meetings to consider the scheme. It is anticipated that the ordinary and special meetings will be held in the first half of November. The directors state that the results of both companies for the year ended March 31 show marked improvement over the previous year.

EDINBURGH CORPORATION has placed a contract for approximately £80,000 with Clarke, Chapman & Company, Limited, of Gateshead-on-Tyne. The order is for boiler plant in connection with extensions to the Portobello power station.

The Order Department

By J. SMITH

There is no department on the commercial side of a modern foundry which is more potent for good or ill than the order department, and the efficiency or otherwise of its organisation is most clearly discernable throughout the whole of the manufacturing stages. The importance of a clear and correct entry of every order received may not inaptly be compared to the laying of good foundations, upon which the future edifice to a great extent depends. Given a correct beginning, the work of production, whether of a large or small order, goes forward smoothly, but without it mistakes and complaints are unavoidable. Much after-sale trouble can be avoided when more attention is devoted to the work of the order department and a clear indication is given of the way in which its duties should be fulfilled.

The Ideal and the Real

A properly-entered internal order should consist of a summarised but perfectly clear statement covering the whole of the transaction, from which there is missing no single item of information whether major or minor. In place of this desirable but perfectly practicable state of things, one far too frequently encounters a summary from which one or two of the most important items of information are altogether omitted. The author has personally had experience of the case of an order being entered up copied textually from the customer's letter which read: "one machine as arranged verbally to-day with Mr. Brown," one result of which was an expensive error in equipment, only to be followed nearly two years later by another, "One machine as before" in which the same expensive error was repeated!

Fundamental Rules

If errors and complaints are to be avoided, it is essential that certain rules should be laid down and rigidly adhered to. The most important of these is that the order as issued to the various departments throughout the works shall be definitely self-explanatory as it stands. In other words, the official order entry (naturally with the necessary drawing referred to therein) should be capable of being correctly executed without any question, or without any reference having to be made to other departments for additional particulars.

The form in which a customer's order should be copied for office and administrative use should contain such information as the following:—(1) Customer and address; (2) price; (3) terms of payment; (4) traveller or agent; (5) customer's order number; (6) customer's order date; (7) carriage (paid or forward); (8) delivery promised by; (9) subsequent delivery promises; (10) forwarding instructions (address to which goods are to be forwarded); (11) date of despatch and advice note number; (12) invoice date and number, and (13) specification of goods ordered.

The first four items are, of course, not necessary for use in all departments, and are frequently omitted from copies to be used in the works departments. It is in connection with the final item, however, in which mistakes are most likely to occur. In the case of any business which takes a long time to mature, it is emphatically not sufficient merely to enter up an order from the wording of the customer's order and the quotation combined. If errors are to be avoided, it is essential also to find out by investigation and careful perusal of correspondence whether any other conditions have been arranged either through salesmen by word of mouth or through correspondence. Careful attention to this point in the first stages will avoid many of the mistakes and misunderstandings arising from slipshod entries of "one machine as arranged verbally."

It is also a wise precaution that a prominent note should be printed at the top of the sheet immediately underneath the heading "Specification" to the effect that the details which follow are the actual specification upon which the quotation has been made and the order placed, and that no variation from such specification is to be permitted in the execution of the order without the consent of the customer and the issue of a duly authorised alteration slip. This precaution is by no means an unnecessary one, as it is a common failing on the part of designers and drawing-office staffs throughout the engineering trade to attempt to make variations in construction or equipment of plant on order as the whim of the moment or the result of later experience may dictate, without any attempt to get the variations authorised.

It is, of course, possible for many such alterations to get through without trouble or question, which is apt to popularise a thoroughly bad procedure, but from time to time this practice will lead to trouble and possibly a heavy counterclaim or deduction on the part of a "difficult" customer, which will indicate that in the long run businesslike procedure in the execution of orders is, in general, both the best and the cheapest. The essential point to be borne in mind is that once a certain description has been quoted and the order placed on that basis, it should not be altered without the approbation of the customer, and a more general appreciation of this point on the part of designers would undoubtedly make for fewer complaints.

Difficulties in Brass Foundry Practice

In many works one finds that in order to obtain complete information upon any customer's order, it is often necessary to make a search in half a dozen departments. In the brass foundry trade where standard patterns are dealt in, it is often the practice to omit the price from the order, this being left until the order has been delivered, when it requires a special invoicing clerk with many years' experience with the firm, and a thorough knowledge of the extra percentages that are added to cover variations in finish, sizes, and other details in order to price the invoice.

For terms of payment, an investigation is necessary into the archives of the accounts department to ascertain whether the customer in question enjoys any special concession. It may be argued that if terms are standard in nine out of ten cases, it is hardly worth while repeating them on the order, but it is probable that the trouble that is caused over the tenth case will show that a clear definition of terms is by no means an idle precaution. In the case of foreign business where the quotation may have stipulated for "cash against shipping documents in London," the writer has encountered instances of the same wording being simply copied out on the order, without any attempt being made in the preliminary stages to ascertain from the customer the name and address of the bank in London where it is proposed that the necessary credit will be opened, and necessitating the holding up of a shipment for weeks while this essential information is cabled for.

Destination

In the case of any printed form or book used for recording inwards orders, a heading should certainly be provided for "forwarding instructions" which will act as a constant reminder that the customer's address is by no means invariably the address to which the goods have to be forwarded, especially when it is a merchant house. There are many export merchants in the city of London who can give instances of attempts being made to give delivery of large boilers or heavy machines of some sort or another to offices in a congested city street, and there are a sufficient number of such mistakes on record to prove the need for some precaution in the way of such a heading which will guard against some momentary lapse of attention or inexperience.

Methods

The old-fashioned order-book, as it used to be kept, is, of course, hopelessly out of date. It suffers from a number of drawbacks. The first is that it has to be laboriously entered up by hand, and probably two or three other similar books used in other departments have also to be copied out in the same manner. Another objection is that it is not sufficiently flexible. A simple order which at the time of entering up consists of about half a dozen lines may before its final execution require two or three pages by reason of the successive alterations and additional instructions that are made from time to time as the order proceeds. The modern system of printed order slips is infinitely preferable, as this method permits of spare copies being taken at the same time for the use of drawing office and various works departments which have to handle the order in its progress towards completion, while at the same time subsequent additions and alterations can be readily made upon loose slips that can be attached to and read as part of the original entry.

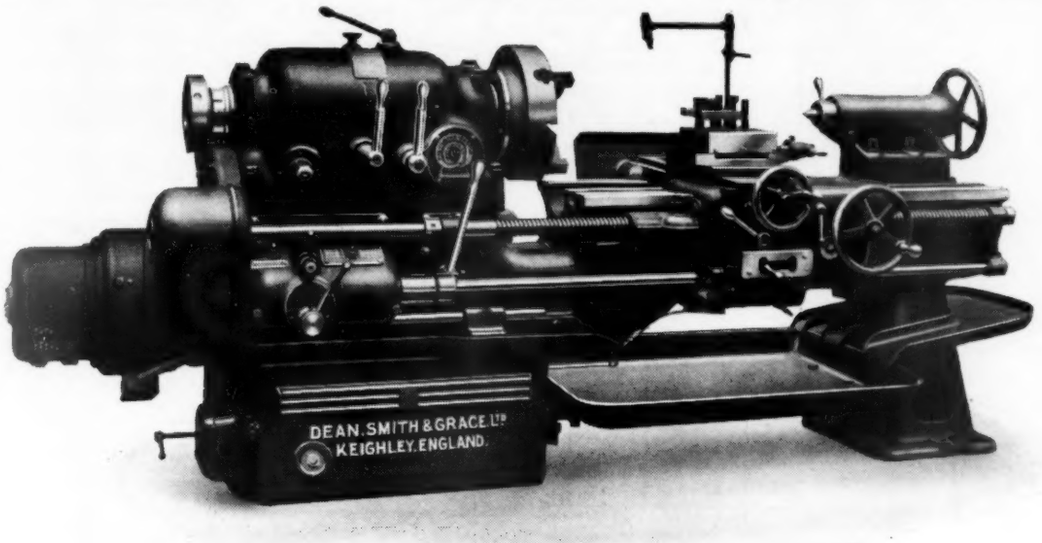
Proper organisation in the order department will be found to cost but little in the way of time or in money, but the results in eliminating the risk of costly mistakes and in speeding up the work of production are of enormous importance, and will in most cases repay a thousandfold the slight trouble involved.

Catalogue Received

Electric Furnaces. A brochure (No. 7) issued by the Electric Development Association, Incorporated, 2, Savoy Hill, London, W.C.2, deals with low-temperature oven work and is meant to be suggestive and to interest users in the subject generally rather than to advocate any particular make of furnace. There is a well-written section on electric furnaces for core baking and this suggested to our mind that inasmuch as three factors are essential for the baking of linseed-oil bonded cores, temperature, time and oxidation of the oil, the electric-furnace manufacturers could make all three factors automatic. Oxidation of the oil could be effected by the introduction of pure oxygen gas in the furnace chamber, it being assumed that such an action would not be too detrimental to the heating elements. The oven could be of a small experimental type, well fitted, and the necessary oxygen could be calculated mathematically to avoid waste. Knowing little about actual costs, we apologise in advance, if the idea is too expensive.

PARTICULARS WERE PUBLISHED last week, to comply with Stock Exchange regulations, of Worthington-Simpson, Limited, which has a capital of £475,000, of which £418,768 is issued and fully paid. There is an authorised loan capital of £200,000 in 4½ per cent. mortgage debentures. The company manufactures, at its works at Newark-on-Trent, power-station equipment for industrial and municipal users, including condensers, feed heaters and evaporators, etc., steam pumps, centrifugal pumps, power pumps and rotary pumps for all industries, shipbuilding pumping machinery, oil pipe-line machinery, oil-refining machinery, refrigerating machinery, and air and gas compressors.

For Heavy Engineering Castings



FOR heavier types of engineering castings, such as those used in lathes, Stanton Low Phosphorus Foundry Pig Iron is particularly suitable. It can be supplied within limits of 0.25% margins of silicon.

The Super High Speed Production Lathe illustrated above is by Dean, Smith & Grace, Limited, of Keighley, who are regular users of

STANTON
LOW PHOSPHORUS FOUNDRY PIG IRON

The largest Producers of Foundry Pig Iron (for Sale) in Great Britain

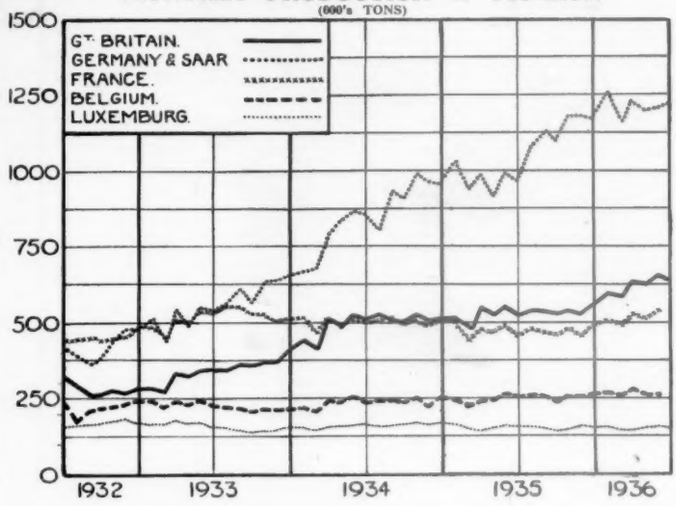
Graph. Carbon %	Comb'd Carbon %	Total Carbon %	Silicon %	Sulphur %	Phos. %	Mang. %
3·35	0·35	3·7	2·5–3·5	0·03–0·05	0·73–0·78	0·9–1·0

The Stanton Ironworks Company Limited, Near Nottingham

The Heavy Industries at a Glance

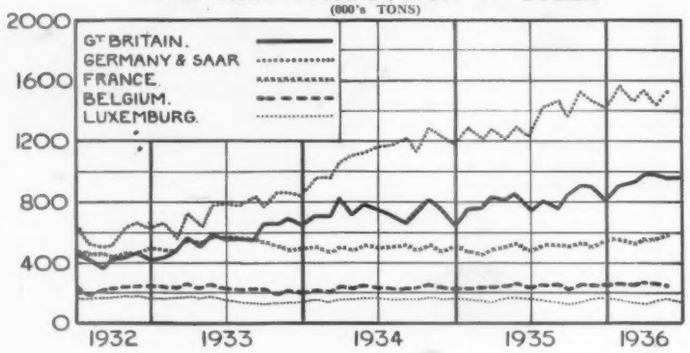
MONTHLY PRODUCTION OF PIG-IRON

(000's TONS)



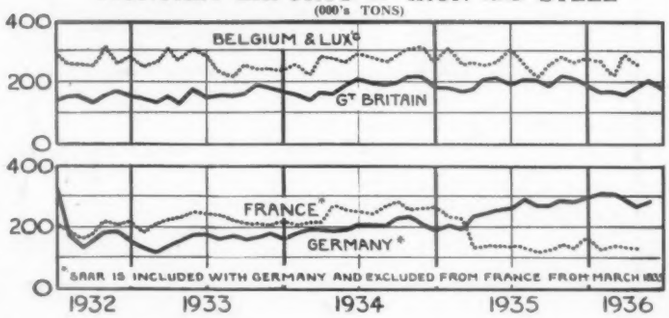
MONTHLY PRODUCTION OF STEEL

(000's TONS)



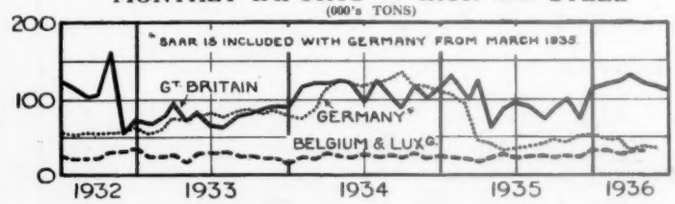
MONTHLY EXPORTS OF IRON AND STEEL

(000's TONS)

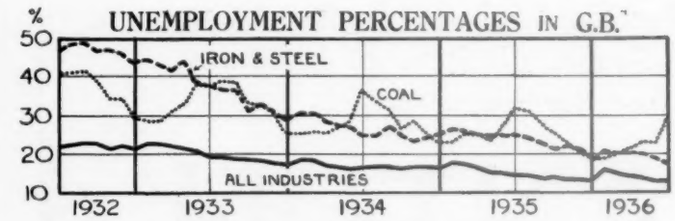


MONTHLY IMPORTS OF IRON AND STEEL

(000's TONS)

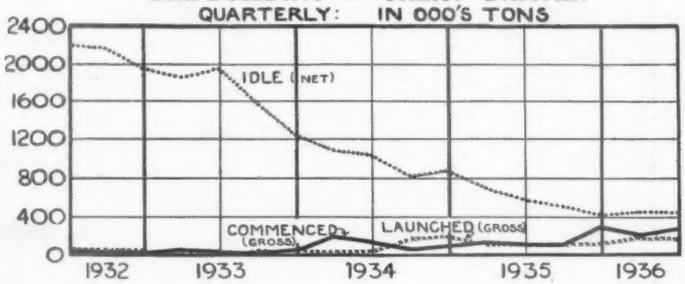


UNEMPLOYMENT PERCENTAGES IN G.B.



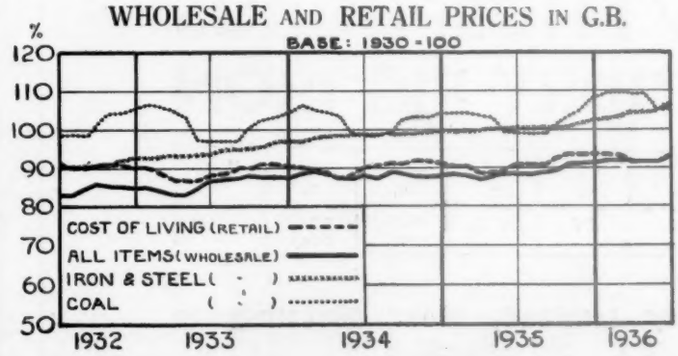
SHIPBUILDING IN GREAT BRITAIN

QUARTERLY: IN 000'S TONS

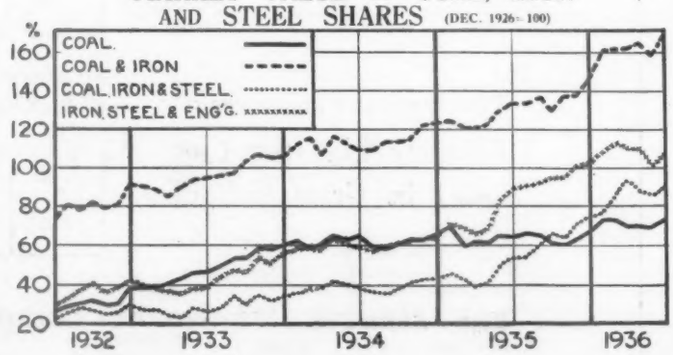


WHOLESALE AND RETAIL PRICES IN G.B.

BASE: 1930-100

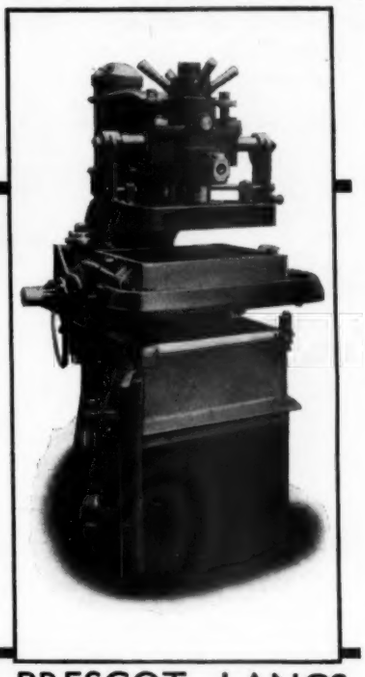


MARKET VALUE OF COAL, IRON AND STEEL SHARES (DEC. 1926=100)



B.I. MAGNETIC MOULDING MACHINES

BRITISH PATENTS 321777, 322728, 349173, 355889



Each machine forms a complete unit.

Construction and control are simple.

Operating costs are very low. Power is only used during the squeeze operation —approximately 2 seconds. Upkeep costs are very small. There are few moving parts, no glands or packings and no troublesome pipe lines.

If only A.C. is available a relatively small A.C./D.C. convertor is required. A sequence relay device allows of operating a battery of machines from one convertor. Electric vibrators and heaters can be supplied if required. All parts are efficiently guarded against ingress of sand. The machine illustrated is model DFB 12/17 for production of complete boxless moulds from double sided pattern plates.

★ *THE ONLY MOULDING MACHINES IN THE WORLD WHICH UTILISE ELECTRICITY AS THE DIRECT POWER MEDIUM FOR HIGH PRODUCTION WORK.*

BRITISH INSULATED CABLES LTD., PRESCOT, LANCS.

Tel. No. Prescot 6571. *London Office*, Surrey House, Embankment, W.C.2. Tel. No. Temple Bar 4793, 4, 5 & 6.

With their world-famous reputation ever in mind Messrs. Leyland Motors Ltd. rather naturally make extensive use of Warner Special Pig Irons in the production of their Cylinder Blocks.

May we quote against *your* specification?

WARNER & CO. LIMITED, CARGO FLEET, MIDDLESBROUGH

The Week's News in Brief

Trade Talk

The United Patternmakers' Association report that the number of unemployed members was 241 last month.

A fire occurred at the works of Jackson, Elphick & Company, Limited, of Larkhall. The fire was confined to the offices of the company, and its work will not be seriously interrupted.

The directors of W. Crockatt & Sons, Limited, engineers, of Glasgow, have announced their decision to grant full pay to all their employees for one week of the annual holiday, commencing at next Glasgow Fair.

J. H. Fenner & Company, Limited, the well-known British manufacturers of flat belts and "V" ropes for power transmission, will be exhibiting a comprehensive range of their products at the British Empire Exhibition, Johannesburg, this autumn.

Sir W. G. Armstrong Whitworth & Company, Limited, have shipped from Stobcross Quay, Glasgow, a 47½-ton Diesel locomotive which they constructed for the Bombay, Baroda & Central India Railway. The engine is the first of its kind to be built for India.

Plymouth Corporation invites tenders for the supply of founders' and smiths' materials. Standard samples are available for inspection in the Corporation's sample room at the Corn Exchange, and tenders on the forms provided have to reach the town clerk by noon on August 26.

The Dalzell Steelworks, Motherwell, belonging to Colvilles, Limited, are to prepare every available steel-melting furnace for operation. Thirteen open-hearth melting furnaces are in active commission at present, and now all the sixteen furnaces are to be prepared, bringing the output up to about 12,000 tons a week.

In connection with the recent wagon orders placed by the L.M.S. and L.N.E. Railway Companies, it is interesting to note that a proportion of these will be built from copper-bearing steel. This steel, containing copper from 0.25 to 0.45 per cent., is in increasing demand where resistance to corrosion is important.

Subject to the settlement of certain details, the Admiralty have placed the orders for two Southampton class cruisers, of the 1936 naval programme, with Harland & Wolff, Limited, Belfast, and Swan, Hunter & Wigham Richardson, Limited, of Wallsend. Machinery for these vessels will be supplied by Wallsend Slipway & Engineering Company, Limited.

In the winter months of 1936-37 a series of twelve public lectures will be delivered by six members of the academic staff of the London School of Economics, on matters of business finance, industrial production and organisation. Admission will be free, and seats will be reserved for holders of tickets which may be obtained from the secretary of the School.

Turnpress, Limited, formerly of Cornwall Street, Openshaw, Manchester, have now taken over the old Burton weaving sheds near Atherton, Lancs. The firm manufactures small parts for nearly every engineering activity in the country. Using brass, copper, nickel, silver and steel as their main materials, they manufacture millions of small parts each year for the electrical, engineering, motor-car, foundry and other industries.

A net profit of $9,070,186, equivalent to 59 cents a share on the common stock, after allowing for the preferred dividend, is reported for the second quarter of 1936 by the International Nickel Company of Canada, Limited. This compares with a net profit of $8,386,787, or 54 cents a share, for the first three months of the current year. Net profits for the first six months of 1936 amount to $17,456,974 (compared with $10,338,242 for the first half of 1935), or $1.13 a share (against 64 cents.).

In the first quarter the output of pig-iron in Czecho-Slovakia was 262,700 tons, and in the second quarter 270,800 tons, making a total of 533,500 tons, compared with 374,100 tons in the first half of 1935, and with only 250,500 tons in 1932, when the depression was at its worst. A similar improvement is registered in the production of crude steel, the output of which in the first half of this year has totalled 699,800 tons, compared with 565,000 tons last year, and only 360,500 tons in 1932.

Personal

Mr. Walter Powell, who for several years has been in charge of the ferro-manganese department of Dorman, Long & Company, Limited, Middlesbrough, has been appointed assistant to the managing director of the Darwen & Mostyn Iron Company, Limited.

Wills

Thornton, Joseph, engineer, of Ordsall Ironworks, Retford	£24,531
Rowell, William, of Chipping Norton, founder of the Hub Ironworks ...	£22,681
Sanderson, Harry Hume, late managing director of Hattersley Bros., Limited, ironfounders	£15,711
Putnam, Sir Thomas, of Darlington, for nearly 40 years managing director of the Darlington Forge, Limited ...	£46,318
Kayser, Julius, of Sheffield, for many years a director of Kayser, Ellison & Company, Limited	£55,494
Greenway, N. W., of Meols, Cheshire, consulting engineer, a director of Gaskell & Chambers, Limited, brass-founders, etc., of Birmingham ...	£22,569

Obituary

Mr. Walter Hume Kerr, formerly lecturer in engineering at Edinburgh University, died recently at the age of 75.

Mr. J. M. Barnes, who for twenty years acted as secretary to the Ayrshire branch of the National Union of Foundry Workers, died recently.

The death has occurred at Toronto, Canada, of Mr. Rowland M. Millar, Vice-President and general manager of the Pease Foundry Company, Limited, Toronto.

Mr. Marshall Stevens, who died on Wednesday at Plymouth, at the age of 84, was one of the founders, and for the first 11 years after the formation of the company the general manager, of the Manchester Ship Canal Company.

Mr. Robert H. Mitchell, who served his apprenticeship with Glenfield & Kennedy, Limited, of Kilmarnock, has died. In 1904 he went to Central America to take up an appointment in the gold mines, and latterly has occupied a post in the gold mines of Ontario.

Company Reports

Hadfields, Limited.—Interim dividend on the ordinary shares of 3¾ per cent.

F. H. Lloyd & Company, Limited.—Final dividend of 5 per cent. on the ordinary shares, making 7 per cent.

W. Canning & Company, Limited.—Interim dividend of 5 per cent. in respect of six months' trading to June 30.

Brightside Foundry & Engineering Company, Limited.—Profit, after depreciation, £37,704; brought in, £17,043; preference dividend, £2,250; dividend of 15 per cent. on the ordinary shares, £15,000; to general reserve account, £19,000; carried forward, £18,497. In view of increasing business the directors have decided to raise additional capital by offering available shares for subscription; 5,000 unissued preference shares and 6,825 ordinary shares are offered at par and 15s. per share premium, respectively. Meeting, August 24.

Fairbairn, Lawson, Combe, Barbour, Limited.—Profit for year to March 31, 1936, of £19,612, subject to depreciation and moratorium interest. The subsidiary companies have earned small profits which have been set off against accumulated losses in the accounts of those companies. The directors consider that the time has come when the capital of the company should be reduced to such a sum as represents more nearly the present capital value of its assets, and that the opportunity should be taken to write off accumulated losses. A scheme has therefore been prepared. Meeting, September 3.

State Insurance Regulations

Recent legislation has necessitated new regulations respecting state insurance measures, and this article will show the employers' and employees' obligations at this period, and at the same time point out the similarities and contrasts between the different branches of insurance. Contribution years under both the Health Insurance and Pensions and the Unemployment Insurance schemes are the same, i.e., July to June. The year 1936 commenced on July 6, but under the former scheme the cards are half yearly and under the latter, in which the cards are termed books, yearly. In July each year an exchange of cards and books must be effected; the cards for Health Insurance and Pensions usually come through the insured persons' approved society. The new card is received by the employee who should exchange it for the old card, fully stamped by the employer. The stamped card is then returned to the relevant society. Unemployment Insurance books are, however, obtainable from any employment exchange and no new book can be secured until the old yearly book is surrendered, since the new book is prepared from the old one.

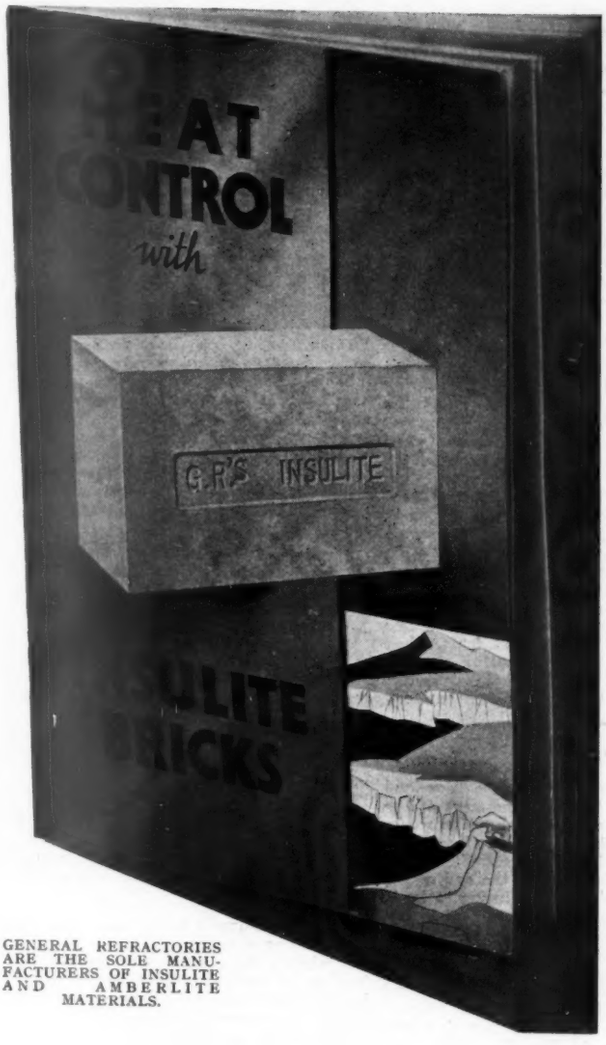
The person responsible for effecting the exchange is the one in whose possession the book is at the relevant date, therefore this duty devolves upon the employer in respect of each person then employed. An employee if he likes can make the exchange himself, but in that case the employer, if he so desires, can demand a receipt for the old book from the employee. Usually a special week is set apart for this operation at exchanges, but an employer may send all his old yearly books to an exchange a short time prior to the end of the contribution year, when the new yearly books are prepared, and the old books are returned for stamping operations. This done, the old books are finally returned to the exchange and the new books can be obtained without delay which sometimes occurs if left until the special week.

To obviate any mistakes that may arise, an employer should always keep a list of the old books sent in, noting the full name of employee and particularly the name of the exchange and number on the front of the book. This may not necessarily be the name of the then operating exchange; it is the name and number of the exchange where the employee first entered for insurance and it is important to the employee that all subsequent years' books to the first should be under that exchange and number as it is under that registration that his contribution account is kept at headquarters. If there is a wrong exchange and number on a book, the persons' credited contributions may not be traced, and difficulty will arise if and when benefit is required. On the other hand, if a book is not replaced properly at the exchange much trouble to the employer usually ensues, and he is asked to obtain various particulars from the relevant employee. With the particulars mentioned above, however, an employer can readily obtain a new book.

Leopold Lazarus, Limited, metal, ore and scrap merchants and exporters, have removed to Creechurch House, Creechurch Lane, London, E.C.3.

Cunard-White Star Line technical and financial experts who have been conferring with John Brown & Company, Limited's, management at Clydebank during the week have returned to Liverpool. Meetings have taken place regarding the details for the construction of Cunarder "552," and an agreement which has been reached will enable the draughtsmen to proceed with the completion of the plans. The berth is ready for the new ship, the keel of which will be laid during November. Colvilles, Limited, will supply the steelwork, which totals more than 70,000 tons.

Write for this NEW booklet



GENERAL REFRACTORIES ARE THE SOLE MANUFACTURERS OF INSULITE AND AMBERLITE MATERIALS.

. . . . it contains information regarding insulation for every user of heat.

General Refractories manufacture three insulating products which are of vital importance to every user of heat. This new booklet describes these three products—Insulite and Amberlite bricks and Insulite Concrete—and also gives instances of how 80% of waste heat may be saved and fuel costs reduced by as much as 20% . . . these products may be used for the heat insulation of open hearth furnaces and regenerator chambers, blast furnace plant (including Cowper stoves), annealing and heat treatment furnaces, blast pipes, hot gas mains, etc., ceramic kilns and ovens, glass furnaces, boiler settings, economisers, and super-heaters, enamelling and general furnaces—whether heated by solid fuel, gas, oil or electricity. All the necessary technical information is also included, so we strongly advise that you write to-day for a free copy.

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Russell House,
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Telephone: Temple Bar 7361
Telegrams:
"Genefax, Rand-London"

Scottish Office:
156, St. Vincent St.,
Glasgow
Telephone: 5250
Telegrams:
"Genefax, Glasgow"

South Wales Office:
11, Wind St.,
Swansea
Telephone: 3680
Telegrams:
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MANUFACTURERS OF HEAT RESISTING AND HEAT INSULATING MATERIALS OF EVERY DESCRIPTION.

Raw Material Markets

Most works are now operating again following the stoppage for holidays and repairs, but the Cleveland area is an exception, this week being the recognised holiday week. Home deliveries are on a good scale, and the outlook for the iron and steel industry is very satisfactory. Conditions are not so favourable in the export market, although some improvement is anticipated in the near future. Following the advance made by the British steelmakers in their export quotations, there has been an increase in the export prices of the Continental Steel Cartel. Finished iron prices are higher following the recent increase in pig-iron.

Pig-Iron

MIDDLESBROUGH.—The annual holiday week is now in progress in this area, and as a result business is negligible. Most works have sufficient supplies with which to restart operations and, indeed, carry them over several weeks. Home consumers are able to take up adequate tonnages as required, and they are not now so insistent in their pressure for deliveries. How long the present firm conditions will last it is difficult to say, but it is known that the engineering works and foundries have well-filled order-books and that their autumn needs are likely to be considerable. Many users have contracts for pig-iron up to the end of the year. It is still difficult for exporters to arrange new business owing to the uncertainty of obtaining supplies. Prices for No. 3 Cleveland G.M.B. delivered to home users are 75s. per ton in the Middlesbrough and Falkirk areas, 77s. on the North-East Coast and 78s. in Glasgow. No. 1 foundry is 2s. 6d. per ton more and No. 4 foundry and No. 4 forge are 1s. per ton less than No. 3.

Almost the whole output of East Coast hematite has been disposed of up to the end of the year. Recent orders include several from users on the West Coast, where makers are reluctant to increase their commitments. Prices for export trade are about 5s. per ton below the home figures, and a few parcels have been despatched. Mixed numbers for home business are 85s. per ton on the North-East Coast, 90s. 6d. in Sheffield, and 96s. in Birmingham, less 5s. per ton rebate to works which buy only from the Hematite Pig-iron Makers' Association.

LANCASHIRE.—Rather quieter conditions have prevailed in this area, and users have been content to draw their supplies from stock. It is estimated that they will be forced to enter the market again some time next month. There is little activity among the textile machinists, but machine-tool makers, heavy electrical engineers, the light-castings trade, and the jobbing foundries are well employed. Offers of Staffordshire and Derbyshire brands of No. 3 foundry iron for delivery in the Lancashire zone are at 83s. per ton, with Northants at 81s. 6d., and Derbyshire forge iron at from 78s. to 80s., according to the class of consumer. Scottish No. 3 is quoted in the region of 90s. per ton, with East Coast hematite at 93s. and West Coast at 93s. 6d., both delivered in this area.

MIDLANDS.—There has been a slight improvement in the delivery position, but producers are hard pressed to maintain the present standard. Prices are unchanged, Northants No. 3 being at 77s. 6d., with Derbyshire, Lincolnshire and North Staffordshire No. 3 at 80s., subject to a small sliding-scale rebate to large users. New business has been restricted, but as soon as the holidays are over a resumption is expected on a large scale. The general engineering concerns and the jobbing foundries are active and have heavy requirements of the special irons. Medium-phosphorus iron is at 82s. 6d. to 90s., with the Scottish grades between 92s. 6d. and 100s. and refined iron between £6 10s. and £8 per ton delivered this area. Steady deliveries of hematite are being made and producers have well-filled order-books extending up to at least the end of the year. It has been announced that the Ford Motor Company have agreed to the scheme of the Hematite Pig-iron Makers' Association. Controlled prices of hematite are £4 17s. for West Coast mixed numbers, £4 16s. for East Coast No. 3 and £4 15s. 6d. for Welsh mixed numbers, less 5s. per ton rebate where applicable.

SCOTLAND.—Consumption of pig-iron is on a good scale against existing contracts, but very little new business has been transacted. Prices remain unchanged, with No. 1 foundry at 81s. 6d. and No. 3 foundry at 79s., f.o.t. furnaces. Rather more Cleveland iron has become available, but it is still very difficult to obtain adequate tonnages. No. 3 Cleveland iron is at 75s., f.o.t. Falkirk, and 78s. f.o.t. Glasgow. Basic iron is in heavy request, and deliveries of both basic and hematite are substantial. There is no change in prices, which are 85s. 6d. for mixed numbers of Scottish, East Coast and West Coast hematite, and 75s. for British and Indian basic, less 5s. rebate, all f.o.t. steelworks.

Coke

Firm conditions have again prevailed on the foundry-coke market, and most consumers have covered, or are in the process of covering, their requirements as far as producers are willing to negotiate. For delivery in Birmingham and district, best Durham coke is quoted between 40s. 6d. and 42s., while Welsh coke ranges from 39s. to 50s. per ton.

Steel

Considerably more activity is noticeable in the steel market than is usual when the holiday season is in full swing, says the official report of the London Iron and Steel Exchange. The volume of new business in the home markets has decreased to some extent owing to local holiday stoppages at works; but deliveries in all departments are still on a heavy scale, and the inquiry on export account shows a tendency to improve. In the semi-finished steel department the producing concerns are operating at capacity, but are scarcely able to satisfy the demand. Some consumers have stocks in hand, but there is an active business passing in small parcels, while most users would be prepared to enter into extended contracts if it were possible. There has been no relaxation of the demand for finished steel materials. The works are operating at capacity, but in many cases are behind in deliveries and are finding it difficult to accept oversea business.

Scrap

Very quiet conditions prevailed on the Cleveland scrap market right up to the commencement of the holidays at the beginning of this week. The works are all well supplied with material, and are consequently remaining out of the market. Some buying is expected to take place before the end of the month, however, and suppliers are refusing to lower prices in the slightest degree. Heavy melting-steel scrap is at 57s. 6d. per ton, with machinery metal at 65s., heavy foundry cast iron 62s. 6d., and clean light cast iron 55s. per ton, delivered works. The tone of the Midlands market remains firm, and there is a good demand for all qualities. Heavy steel in furnace sizes is at 52s. 6d., and mixed heavy iron and steel 50s. to 51s. 6d. Heavy unsheared wrought iron receives few inquiries at 65s. to 67s. 6d. Heavy machinery in handy sizes is at 70s., good heavy pipe and plate at 65s., and clean light scrap at 55s. Short, heavy steel, as used in the foundries, is at 65s. to 67s. 6d. per ton, delivered works. On the Yorkshire market the demand generally is inclined to be quiet. Foundry cast iron at 67s. 6d. has been less active, while a moderate demand exists for light cast iron at around 55s. Only a small inquiry is noted for steelworks heavy cast iron at 54s. Heavy wrought shearing iron is quoted around 67s. 6d. per ton. Fairly active conditions continue to prevail on the Scottish market. Deliveries have been maintained on a good scale. Heavy steel scrap is at 57s. 6d., with basic or heavy iron and steel scrap mixed, at 5s. less. Heavy machinery cast-iron scrap, in pieces not exceeding 1 cwt., is around 67s. 6d. to 70s., with ordinary cast iron, to the same specification, 64s. to 65s. per ton, delivered f.o.t. consumers' works.

Metals

Copper.—The price of standard copper reached a new high level for this year during the past week, following the report of activity in the United States. The holiday interruptions have again kept industrial interest at a low ebb, but the market is distinctly firm. A further rise in the United States price to 10 cents per pound is expected in New York. The export quotation last Thursday was raised another 5 points to 9¾ cents—the same as the domestic figure, which is a very unusual state of affairs. World stocks of refined copper at July 31 totalled 432,322 short tons, a fall of 26,592 tons on the month. United States stocks declined by 10,112 to 218,705 tons. World consumption last month reached 146,042 tons, compared with 142,281 tons in June.

Daily market prices :—

Cash.—Thursday, £38 12s. 6d. to £38 13s. 9d.; Friday, £38 15s. to £38 16s. 3d.; Monday, £38 7s. 6d. to £38 8s. 9d.; Tuesday, £38 2s. 6d. to £38 3s. 9d.; Wednesday, £38 2s. 6d. to £38 3s. 9d.

Three Months.—Thursday, £38 17s. 6d. to £38 18s. 9d.; Friday, £39 to £39 1s. 3d.; Monday, £38 13s. 9d. to £38 15s.; Tuesday, £38 7s. 6d. to £38 10s.; Wednesday, £38 7s. 6d. to £38 8s. 9d.

Tin.—There has been little business transacted in tin, either in the United Kingdom or in the United States. Chief interest continues to be centred in Siam's attitude towards the renewal of restriction. In this connection Mr. Lowinger, the International Tin Committee delegate, has stated that the negotiations with Siam have been proceeding on the friendliest terms. They were unable to concede to Siam the large minimum tonnage which was denied to other countries, but there was no reason for saying that negotiations had broken down. An official statement would be published after the International Tin Committee meeting on September 18, but further negotiations would be possible till the end of the year. If no agreement were reached with Siam, the restriction scheme would completely collapse, added Mr. Lowinger.

Metal Exchange quotations were as follow :—

Cash.—Thursday, £181 7s. 6d. to £181 10s.; Friday, £182 10s. to £182 15s.; Monday, £181 to £182 15s.; Tuesday, £181 to £181 10s.; Wednesday, £184 5s. to £184 15s.

Three Months.—Thursday, £178 to £178 10s.; Friday, £179 to £179 10s.; Monday, £177 15s. to £178; Tuesday, £178 to £178 5s.; Wednesday, £181 5s. to £181 10s.

Spelter.—This market has a steady appearance, though buying on industrial account is only moderate. In many quarters it is still believed that a meeting in connection with the reconstitution of the Zinc Cartel will be held either next or the following month, but there is a lack of official information.

Official quotations were as follow :—

Ordinary.—Thursday, £13 10s.; Friday, £13 10s.; Monday, £13 10s.; Tuesday, £13 8s. 9d.; Wednesday, £13 8s. 9d.

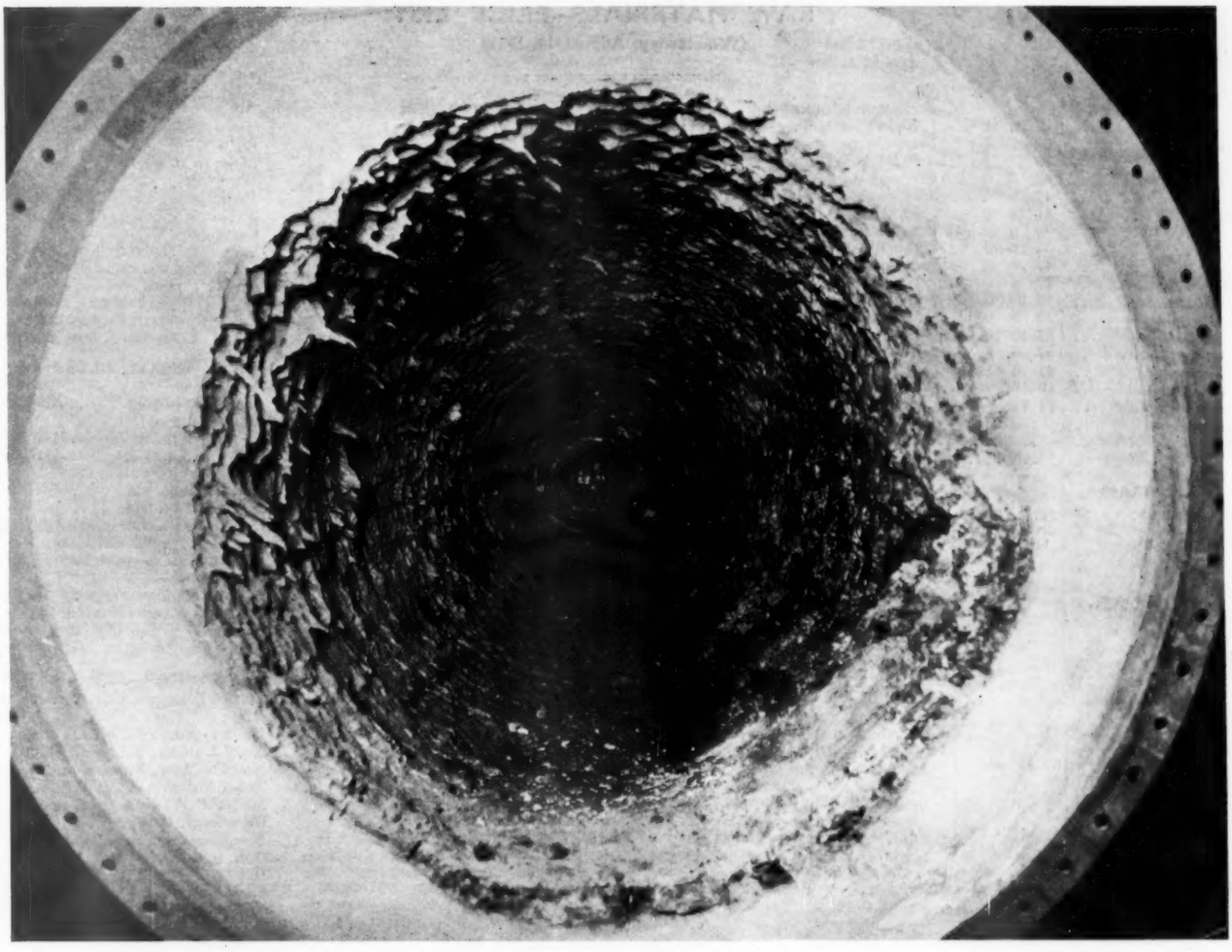
Lead.—Consumers have been very spasmodic in their buying recently, but the market has continued to maintain its steady tone. In the United States buying is moderate, but the volume of business booked during July is reported to have been the largest for a considerable period.

Day-to-day quotations :—

Soft Foreign (Prompt).—Thursday, £16 16s. 3d.; Friday, £16 15s.; Monday, £16 13s. 9d.; Tuesday, £16 11s. 3d.; Wednesday, £16 13s. 9d.

Protective Glasses for Electric Welders

"Lamurex" protective glass for welders is manufactured by Murex Welding Processes, Limited, Ferry Lane Works, Forest Road, Walthamstow, London, E.17, on a principle which makes the production of a protective glass of standard density a simple matter. It consists of a special form of light filter of definite thickness and predetermined colour density cemented between two sheets of glass. In order to meet the requirements of various trades these protective glasses are made in three densities as follow:—Grade 1: Suitable for light welding operations and currents up to 100 amps.; Grade 2: suitable for ordinary welding operations and current up to 200 amps.; Grade 3: suitable for heavy welding operations and large gauge electrodes. The "Lamurex" glasses deal so efficiently with "fatigue rays" that it is possible to allow a larger quantity of light to pass through them, without impairing their efficiency, than is usually possible with normal types. The welder thus not only sees his electrode and arc more clearly, but the surrounding areas are also clearly visible, thus making for easier and better workmanship.



950 tons of metal melted—

The above photograph shows the condition of an 04 grade Albino lining in a 5-ton Brackelsberg furnace after 255 heats. You will observe the lining has worn back evenly and it is still approximately 8" in thickness. The 04 grade is specially produced for rotary furnaces, but there are other grades for lining cupolas, converters and ladles.
This photograph is reproduced by courtesy of James Howden and Company (Land) Ltd.

ALBINO

ROTARY FURNACE LINING MATERIAL

Please write for further particulars to the sole manufacturers:

GENERAL REFRACTORIES LIMITED,

Genefax House, Sheffield, 10

Telephone: Sheffield 31113 (6 lines) Telegrams: "Genefax, Sheffield"

MANUFACTURERS OF HEAT RESISTING AND HEAT INSULATING MATERIALS OF EVERY DESCRIPTION.

RAW MATERIALS—PRICE LIST

(Wednesday, August 19, 1936)

COPPER

	£	s.	d.
Standard cash	38	2	6
Three months	38	7	6
Electrolytic	42	5	0
Tough	41	5	0
Best selected	41	15	0
Sheets	70	0	0
India	52	0	0
Wire bars	43	0	0
Ingot bars	43	0	0
H.C. wire rods	46	10	0
Off. av. cash, July	37	5	0 1/16
Do., 3 mths., July	37	10	10 3/16
Do., Sttlmnt., July	37	5	2 3/16
Do., Electro, July	41	8	7 3/16
Do., B.S., July	40	19	8 1/2
Do., wire bars, July	41	12	8 1/16
Solid drawn tubes			10 1/2d.
Brazed tubes			10 1/2d.
Wire			6 1/2d.

BRASS

Solid drawn tubes	9 1/2d.
Brazed tubes	11 1/2d.
Rods, drawn	8 1/2d.
Rods, extd. or rlld.	5d.
Sheets to 10 w.g.	8d.
Wire	7 1/2d.
Rolled metal	7 1/2d.
Yellow metal rods	5d.
Do. 4 × 4 Squares	5 1/2d.
Do. 4 × 3 Sheets	5 1/2d.

TIN

	£	s.	d.
Standard cash	184	5	0
Three months	181	5	0
English	184	10	0
Bars	186	5	0
Straits	189	5	0
Australian	184	5	0
Eastern	185	7	6
Banca	187	5	0
Off. av. cash, July	186	4	5 1/16
Do., 3 mths., July	182	12	0 3/16
Do., Sttlmt., July	186	2	9 1/16

SPELTER

	£	s.	d.
Ordinary	13	8	9
Remelted	13	0	0
Hard	11	10	0
Electro 99.9	15	10	0
English	14	7	6
India	12	10	0
Zinc dust	19	10	0
Zinc ashes	4	5	0
Off. aver., July	13	14	0 7/16
Aver. spot, July	13	11	6 1/16

LEAD

	£	s.	d.
Soft foreign ppt.	16	13	9
Empire	17	6	3
English	18	15	0
Off. average, July	15	18	1 5/16
Average spot, July	15	17	1 13/16

ALUMINIUM

Ingots	£100 to £105
Wire	1/3 to 1/4 lb
Sheet and foil	1/2 to 1/4 lb.

ZINC SHEETS, &c.

	£	s.	d.	£	s.	d.
Zinc sheets, English	24	0	0 to	24	10	0
Do., V.M. ex-whse.	24	0	0 to	24	10	0
Rods				25	10	0

ANTIMONY

	£	s.	d.	£	s.	d.
English	64	10	0 to	65	10	0
Chinese, ex-whse.				51	0	0
Crude, c.i.f.				23	0	0

QUICKSILVER

	£	s.	d.	£	s.	d.
Quicksilver	11	15	0 to	12	3	6

FERRO-ALLOYS AND STEEL-MAKING METALS

Ferro-silicon—						
25%				8	17	6
45/50%	11	10	0 to	12	15	0
75%	16	12	6 to	17	17	6
Ferro-vanadium—						
35/50%				12/8 lb. Va.		
Ferro-molybdenum—						
70/75% carbon-free				4/6 lb. Mo.		
Ferro-titanium—						
20/25% carbon-free				9d. lb.		
Ferro-phosphorus, 20/25%				£21 to £22		
Ferro-tungsten—						
80/85%				3/- lb.		
Tungsten metal powder—						
98/99%				3/1 1/2 lb.		
Ferro-chrome—						
2/4% car.				33	0	0
4/6% car.				21	10	0
6/8% car.				21	0	0
8/10% car.				21	0	0
Ferro-chrome—						
Max. 2% car.				33	10	0
Max. 1% car.				36	5	0
Max. 0.50% car.				37	5	0
70% carbon-free				9 1/2d. lb.		
Nickel—99.5/100%				£200 to £205		
"F" nickel shot				£184	0	0
Ferro-cobalt, 98/99%				6/3 to 6/9 lb.		
Metallic chromium—						
96/98%				2/5 lb.		
Ferro-manganese—						
76/80% loose	£11	5	0 to	11	15	0
76/80% packed	£12	5	0 to	12	15	0
76/80% export	(nom.)	£10	5	0		
Metallic manganese—						
94/96% carbon-free				1/3 lb.		

Per ton unless otherwise stated, basis 2-ton lots.

HIGH-SPEED TOOL STEEL

Finished bars, 14% tungsten	2s. 0d.
Finished bars, 18% tungsten	2s. 9d.

Per lb. net, d/d buyers' works.

Extras—	
Rounds and squares, 3 in. and over	4d. lb.
Rounds and squares, under 1/2 in. to 1/4 in.	3d. lb.
Do., under 1/4 in. to 1/16 in.	1/- lb.
Flats, 1/4 in. × 1/4 in. to under 1 in. × 3/8 in.	3d. lb.
Do., under 1/4 in. × 1/4 in.	1/- lb.
Bevels of approved sizes and sections	6d. lb.

Bars cut to length, 10% extra.

SCRAP

	£	s.	d.	£	s.	d.
South Wales—						
Heavy steel	3	2	0 to	3	3	0
Mixed iron and steel	2	18	0 to	3	0	0
Heavy cast iron	2	18	0 to	3	0	0
Good machinery	3	2	0 to	3	4	0
Cleveland—						
Heavy steel				2	17	6
Steel turnings				2	0	0
Heavy cast iron				3	2	6
Heavy machinery				3	5	0
Midlands—						
Light cast-iron scrap				2	15	0
Heavy wrought iron	3	5	0 to	3	7	6
Steel turnings				2	0	0
Scotland—						
Heavy steel				2	17	6
Ordinary cast iron	3	4	0 to	3	5	0
Engineers' turnings				2	2	0
Cast-iron borings				1	17	6
Wrot-iron piling	3	7	6 to	3	10	0
Heavy machinery	3	7	6 to	3	10	0

London—Merchants' buying prices, delivered yard.

	£	s.	d.
Copper (clean)	30	0	0
Brass	19	10	0
Lead (less usual draft)	15	0	0
Tea lead	10	15	0
Zinc	8	10	0
New aluminium cuttings	74	0	0
Braziery copper	28	0	0
Gunmetal	29	0	0
Hollow pewter	138	0	0
Shaped black pewter	105	0	0

PIG-IRON

N.E. Coast (d/d Tees-side area)—	
Foundry No. 1	77/6
,, No. 3	75/-
,, No. 4	74/-
Forge No. 4	74/-
Hematite No. 1	85/6*
Hematite M/Nos.	85/-*
N.W. Coast—	
Hem. M/Nos. d/d Glas.	85/6*
,, d/d Birm.	97/-*
Malleable iron d/d Birm.	125/-
Midlands (d/d Birmingham dist.)—	
Staffs No. 4 forge	77/-
,, No. 3 fdry.	80/-
Northants forge	74/6
,, fdry. No. 3	77/6
,, fdry. No. 1	80/6
Derbyshire forge	77/-
,, fdry. No. 3	80/-
,, fdry. No. 1	83/-
Scotland—	
Foundry, No. 1, f.o.t.	81/6
,, No. 3, f.o.t.	79/-
Cleveland No. 3, Glasgow	78/-
,, ,, Falkirk	75/-
Scottish hem. M/Nos. d/d	85/6*
Sheffield (d/d district)—	
Derby forge	74/6
,, fdry. No. 3	77/6
Lincs forge	74/6
,, fdry. No. 3	77/6
W.C. hematite	91/-*
Lancashire (d/d eq. Man.)—	
Derby fdry. No. 3	83/-
Staffs fdry. No. 3	83/-
Northants fdry. No. 3	81/6
Cleveland fdry. No. 3	83/-
Dalzell, No. 3 (special)	102/6 to 105/-
Glengarnock, No. 3	90/-
Clyde, No. 3	90/-
Monkland, No. 3	90/-
Summerlee, No. 3	90/-
Eglinton, No. 3	90/-
Gartsherrie, No. 3	90/-
Shotts, No. 3	90/-

* Subject to a rebate of 5s. per ton under certain conditions.

FINISHED IRON AND STEEL

Usual district deliveries for iron; delivered consumer's station for steel.

	£	s.	d.	£	s.	d.
Iron—						
Bars (cr.)				10	10	0
Nut and bolt iron	8	10	0 to	9	0	0
Hoops			11 7 6 and up.			
Marked bars (Staffs) f.o.t.				13	0	0
Gas strip			11 7 6 and up.			
Bolts and nuts, 1/4 in. × 4 in.			15 15 0 and up.			
Steel—						
Plates, ship, etc.	9	7	6 to	9	10	0
Boiler plts.	9	17	6 to	10	0	0
Chequer plts.				11	0	0
Angles				9	0	0
Tees				10	0	0
Joists				9	7	6
Rounds and squares, 3 in. to 5 1/2 in.				10	0	0
Rounds under 3 in. to 1/4 in. (Untested)				9	7	0
Flats—8 in. wide and over				9	5	0
,, under 8 in. and over 5 in.				9	10	0
Rails, heavy	8	5	0 to	8	10	0
Fishplates				12	10	0
Hoops (Staffs)				10	2	0
Black sheets, 24g. (4-t. lots)				12	0	0
Galv. cor. shts. (,,)				14	0	0
Galv. flat shts. (,,)				14	10	0
Galv. fencing wire, 8g. plain				15	0	0
Billets, soft				6	2	6
Billets, hard	7	2	6 to	7	7	6
Sheet bars				6	0	0
Tin bars				6	0	0

PHOSPHOR BRONZE

	Per lb. basis
Strip	10 1/2d.
Sheet to 10 w.g.	11 1/2d.
Wire	12 1/2d.
Rods	11 1/2d.
Tubes	14d.
Castings	12 1/2d.

Delivery 3cwt. free.
10% phos. cop. £30 above B.S.
15% phos. cop. £35 above B.S.
Phosphor tin (5%) £30 above price of English ingots.
C. CLIFFORD & SON, LIMITED.

NICKEL SILVER &c.

	Per lb.
Ingots for raising	7d. to 1/1
Rolled—	
To 9 in. wide	1/1 to 1/7
To 12 in. wide	1/1 1/2 to 1/7 1/2
To 15 in. wide	1/1 3/4 to 1/7 1/2
To 18 in. wide	1/2 to 1/8
To 21 in. wide	1/2 1/2 to 1/8 1/2
To 25 in. wide	1/3 to 1/9
Ingots for spoons and forks	7d. to 1/3 1/2
Ingots rolled to spoon size	10d. to 1/6 1/2
Wire round—	
to 10g.	1/4 1/2 to 1/11 1/2

with extras according to gauge.
Special 5ths quality turning rods in straight lengths, 1/3 1/2 upwards.

AMERICAN IRON AND STEEL

At Pittsburgh unless otherwise stated.

	Dols.
No. 2 foundry, Phila.	21.31
No. 2 foundry, Valley	19.50
No. 2 foundry, Birm.	15.50
Basic, Valley	19.00
Malleable, Valley	19.50
Grey forge, Valley	19.00
Ferro-mang. 80%, seaboard	75.00
O.-h. rails, h'y, at mill	36.37 1/2
Billets	30.00
Sheet bars	30.00
Wire rods	38.00
	Cents.
Iron bars, Chicago	1.80
Steel bars	1.95
Tank plates	1.90
Beams, etc.	1.90
Skelp, grooved steel	1.80
Steel hoops	1.95
Sheets, black, No. 24	2.50
Sheets, galv., No. 24	3.20
Wire nails	2.10
Plain wire	2.40
Barbed wire, galv.	2.60
Tinplates, 100-lb. box	$5.25

COKE (at ovens)

Welsh foundry	30/- to 31/-
,, furnace	24/6 to 25/-
Durham foundry	24/6
,, furnace	21/6
Scotland, foundry	30/-
,, furnace	25/- to 26/-

TINPLATES

f.o.b. Bristol Channel ports.

I.C. cokes	20×14 per box	18/9
,,	28×20 ,,	37/6
,,	20×10 ,,	26/9 to 27/3
,,	18 3/4×14 ,,	19/6 to 19/9
C.W.	20×14 ,,	15/9 to 16/-
,,	28×20 ,,	33/9 to 34/3
,,	20×10 ,,	22/6 to 23/-
,,	18 3/4×14 ,,	15/3 to 15/9

SWEDISH CHARCOAL IRON & STEEL

	£	s.	d.	£	s.	d.
Pig-iron	£6	0	0 to	£7	0	0
Bars-hammered, basis	£16	0	0 to	£16	10	0
Bars and nail-rods, rolled, basis	£15	15	0 to	£16	0	0
Blooms	£10	0	0 to	£12	0	0
Keg steel	£25	0	0 to	£28	0	0
Faggot steel	£18	0	0 to	£23	0	0
Bars and rods dead soft, st'l	£10	0	0 to	£12	0	0

All per English ton, f.o.b. Gothenburg.
[Subject to an exchange basis of Kr. 18.16 to £1.]

DAILY FLUCTUATIONS

Standard Copper (cash)

	£ s. d.	
Aug. 13 ..	38 12 6 inc.	5/–
„ 14 ..	38 15 0 „	2/6
„ 17 ..	38 7 6 dec.	7/6
„ 18 ..	38 2 6 „	5/–
„ 19 ..	38 2 6 No change	

Electrolytic Copper

	£ s. d.	
Aug. 13 ..	42 15 0 inc.	5/–
„ 14 ..	43 0 0 „	5/–
„ 17 ..	42 15 0 dec.	5/–
„ 18 ..	42 0 0 „	15/–
„ 19 ..	42 5 0 inc.	5/–

Standard Tin (cash)

	£ s. d.	
Aug. 13 ..	181 7 6 dec.	57/6
„ 14 ..	182 10 0 inc.	22/6
„ 17 ..	181 0 0 dec.	30/–
„ 18 ..	181 0 0 No change	
„ 19 ..	184 5 0 inc.	65/–

Tin (English ingots)

	£ s. d.	
Aug. 13 ..	181 10 0 dec.	50/–
„ 14 ..	182 10 0 inc.	20/–
„ 17 ..	181 0 0 dec.	30/–
„ 18 ..	181 5 0 inc.	5/–
„ 19 ..	184 10 0 „	65/–

Spelter (ordinary)

	£ s. d.	
Aug. 13 ..	13 10 0 inc.	2/6
„ 14 ..	13 10 0 No change	
„ 17 ..	13 10 0 „ „	
„ 18 ..	13 8 9 dec.	1/3
„ 19 ..	13 8 9 No change	

Spelter (Electro, 99.9 per cent.)

	£ s. d.	
Aug. 13 ..	15 10 0 inc.	2/6
„ 14 ..	15 10 0 No change	
„ 17 ..	15 10 0 „ „	
„ 18 ..	15 10 0 „ „	
„ 19 ..	15 10 0 „ „	

Lead (soft foreign, prompt)

	£ s. d.	
Aug. 13 ..	16 16 3 inc.	3/9
„ 14 ..	16 15 0 dec.	1/3
„ 17 ..	16 13 9 „	1/3
„ 18 ..	16 11 3 „	2/6
„ 19 ..	16 13 9 inc.	2/6

Lead (English)

	£ s. d.	
Aug. 13 ..	18 15 0 No change	
„ 14 ..	18 15 0 „	„
„ 17 ..	18 15 0 „	„
„ 18 ..	18 15 0 „	„
„ 19 ..	18 15 0 „	„

Imports and Exports of Pig-Iron and Steel Castings, etc., in July, and the Seven Months 1936, compared with July, and the Seven Months 1935.

	July.		Seven months.		July.		Seven months.	
	1935.	1936.	1935.	1936.	1935.	1936.	1935.	1936.
	Tons.	Tons.	Tons.	Tons.	£	£	£	£
Imports.								
Pig-iron—from British India	4,300	9,687	43,225	54,186	13,054	30,562	131,044	169,339
„ Foreign Countries	674	10,235	8,008	31,254	3,720	29,598	46,785	127,867
Total	4,974	19,922	51,233	85,440	16,774	60,160	177,829	297,206
Castings and forgings	318	347	1,673	4,664	8,144	15,402	43,251	160,821
Cast pipes and fittings	340	253	956	837	5,057	7,460	22,692	28,333
Stoves and grates, etc.	254	161	783	505	15,378	9,929	63,886	47,896
Baths	804	1,030	4,094	4,257	21,281	23,661	110,409	105,327
Hollow-ware, all kinds	195	331	1,477	2,078	12,985	17,578	99,288	113,067
Exports.								
Pig-iron, forge and foundry	8,733	5,367	55,527	32,828	28,255	20,542	192,718	124,370
„ acid	3,249	6,141	29,528	22,446	10,540	24,040	96,000	80,901
„ basic	—	—	231	108	—	—	727	557
Total	11,982	11,508	85,286	55,382	38,795	44,582	289,445	205,828
Castings and forgings	457	305	2,511	2,427	14,767	12,604	95,445	92,331
Cast pipes and fittings, up to 6 in. diameter	4,739	5,371	32,700	32,213	52,331	58,827	360,992	361,822
„ „ „ over 6 in.	2,228	3,559	21,764	23,918	19,611	28,733	169,209	195,154
Stoves, grates, etc.	696	778	4,824	5,740	37,409	40,872	241,942	295,864
Sanitary cisterns	292	289	1,821	1,793	9,333	8,430	52,910	55,817
Bedsteads, including tubes therefor	344	419	2,442	2,801	11,981	15,885	90,050	105,378
Cast hollow-ware	368	541	2,254	3,199	12,892	19,958	86,446	114,697

WILLIAM JACKS & COMPANY,
WINCHESTER HOUSE, OLD BROAD ST., LONDON, E.C.2.

CLARENCE CHAMBERS, 39, CORPORATION STREET, BIRMINGHAM.
13, RUMFORD STREET, LIVERPOOL.

PIG IRON

REGISTERED TRADE MARK

FOR EVERY TYPE OF CASTING

NON-FERROUS METALS

REFRACTORIES — COKE — SAND
FERRO-SILICON—FERRO-CHROME

WILLIAM JACKS & COMPANY,
CENTRAL CHAMBERS, 93, HOPE ST., GLASGOW, C.2.
ZETLAND ROAD, MIDDLESBROUGH.

SITUATIONS VACANT AND WANTED

CUPOLA MAN, under 40, with eighteen years' varied experience, desires situation anywhere. Clean, safe tapping, no hard holes; do own bricking; familiar with balanced-blast type cupola. Really dependable reference.—Box 848, Offices of THE FOUNDRY TRADE JOURNAL, 49, Wellington Street, Strand, London, W.C.2.

FOUNDRY ENGINEER desires to represent manufacturers of Core Oils, Mixers, etc., in London and Home Counties. 24 years' experience Foundry Trade. Own car. M.I.B.F.—Box 854, Offices of THE FOUNDRY TRADE JOURNAL, 49, Wellington Street, Strand, London, W.C.2.

FOUNDRY MANAGER, with knowledge of alloy cast-iron pressure castings, cylinders for motor and other trades, wishes to meet firm interested. Technical and commercial experience.—Box 822, Offices of THE FOUNDRY TRADE JOURNAL, 49, Wellington Street, Strand, London, W.C.2.

FOUNDRY MANAGER wanted to take charge of approximately 100 men. Must have experience in grey and white iron, for engineering works in Manchester district. Full particulars of experience and salary to Box 852, Offices of THE FOUNDRY TRADE JOURNAL, 49, Wellington Street, Strand, London, W.C.2.

IRONFOUNDRY FOREMAN required to supervise modern Foundry equipped with Sandslinger and designed to produce 25 tons of castings per week.—S. RUSSELL & SONS, LIMITED, Bath Lane, Leicester.

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